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# AERO/SPACE ENGINEERING

REVIEW OF CURRENT AND FUTURE TRENDS IN AIRCRAFT • MISSILES • ROCKETS • SATELLITES • SPACECRAFT

Exploring the Moon (cover illustration) • Fatigue Problem Analysis • The Indispensible Pilot • Design and Tunnel Testing • Growth of an Airplane • Measuring Acceleration • Aerospace Literature (304 Abstracts in this issue)

NOVEMBER / 1959

# *Birth of a Notion*

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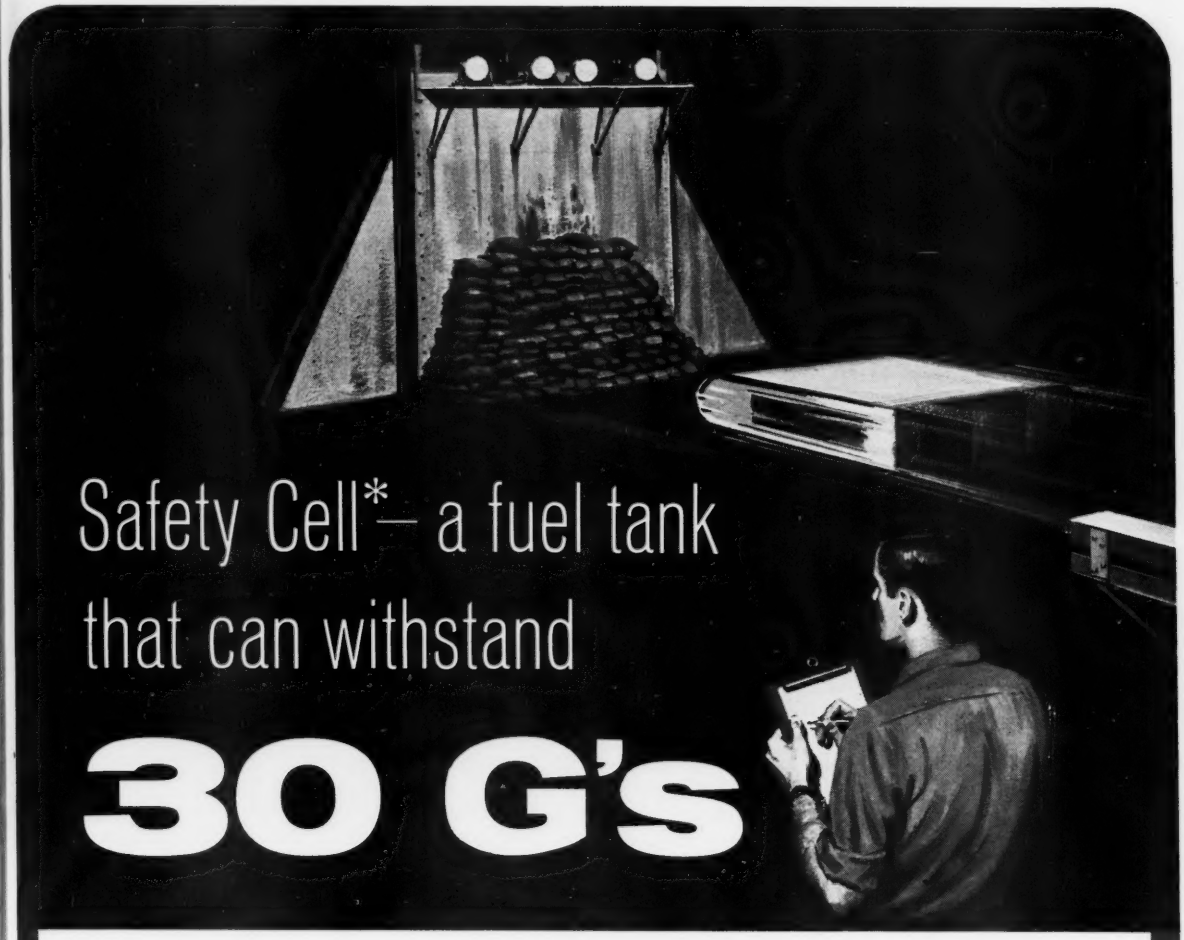

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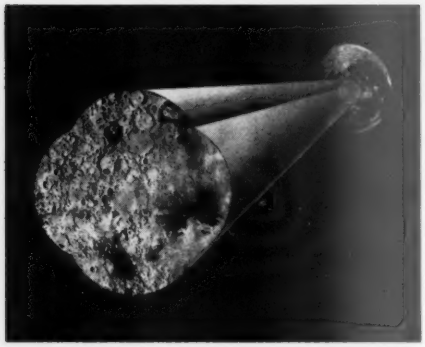

### Our cover . . .

*. . . illustrates this month's leading article, which points out the possible value of probing the surface of the moon by radar unencumbered by the Earth's ionosphere. Arcs on the expanded portion define lunar circular areas from which most radar echoes are received on Earth. These are the arcs of circles corresponding to 300μs radar "depths." Depending on the position of the moon in its orbit, slightly different areas also will return echoes, according to authors W. E. Fensler, T. B. A. Senior, and K. M. Siegel, of The University of Michigan Radiation Laboratory. They suggest placing a radar-equipped satellite in orbit around the moon—a feat believed possible by using hardware under development.*
*—Lick Observatory photos*


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# AERO/SPACE ENGINEERING

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# Letters

### More on Newton

■ I want to thank Mr. Juan Todaro, TMIAS (*A/SE* "Letters" last month), for his interest in my observations published in your Letters to the Editor section in July.

I could never find anything wrong with Newton's mathematics, but I believe he went astray when he tried to solve many of the problems of our universe by means of Gravitational Forces or Mutual Attractions. The Laws of Expansion and Diffusion of Gases belie Newton's Law of Mutual Attraction.

Here we have Atoms of Materials which have very definite weights. They do not attract, but positively repel each other.

According to Newton's own math, any two bodies would be drawn together or separated, unless their gravitational forces were balanced, by a centrifugal force of equal value.

I could imagine this condition for two planets, but in our solar system with a central sun and nine planets revolving at nine different velocities at nine different distances, sometimes bunched together, sometimes far apart, and each having an attraction for each other as well as for the sun. . . . This clearly is beyond my power of reasoning.

I would rather place my faith in the same atomic forces which build up our complicated atoms with their shells and subshells. The spectroscope tells us these forces exist. We do not know what they are because we cannot duplicate them in the laboratory.

The meteoric dust that daily pelts the earth has been found to contain 31 of our elements. The more combustible elements such as sodium, phosphorous, magnesium, etc. (the kind we keep in water to prevent spontaneous combustion) are lost by oxidation as these particles pass through the oxygen layer some 200 miles up.

These particles do not burn up as commonly supposed. They travel at a constant velocity until these volatile metals are completely oxidized. When the phosphorescent light goes out, the rest of the metal is not even red hot.

If these particles burned completely, they would become progressively brighter and would slow down to a complete stop with a ball of fire.

The way they travel, they seem to lose only a small percentage of their weight.

As for the tides, expansion and contraction are definitely thermal forces.

I stated that inertial guidance systems depending on accelerometers and gyroscopes are worthless under weightless conditions.

Mass equals weight in motion, or weight divided by gravity, or weight no matter how you disguise it. You cannot work any mathematical problem with mass until your convert it into weight; therefore, when mass or weight equals nothing, there can be no work done.

As for heat dissipation, to convert heat into light would be quite a heavy and costly way to get rid of heat here on earth.

An "unstable" body is free to move in any direction. When you are tumbling around in space with no stable reference table to refer to, you have no way of knowing where you have been or where you are trying to get to. (I cannot imagine a more difficult position to be in.) Moreover, frictionless and weighless flight is economical, whereas if you have to introduce sources of power to cause friction in an effort to try and control an unstable body, it might make interplanetary space travel quite impractical, if not impossible.

**Frederick Charavay, AFIAS**

✦ ✦ ✦

### Navy's CNO Lauds ASW Conclave

■ Several oral reports on the excellence of the IAS Symposium on Anti-Submarine Warfare had preceded your kind letter of September 2 which so expressively confirmed them. We are very grateful to the IAS for the splendid opportunity given the Navy to present the ASW problem to such an important and competent segment of the U.S. research and industrial fraternities. It also is gratifying that the Navy cooperation met with the approval of the participants. Your expressions of appreciation have been passed along.

As you stated, the ASW problem is as serious a threat as any our nation faces. Our ASW forces are composed of dedicated people who are working hard to keep on top of this grave menace to our control of the seas. Various factors, of which you are aware, limit their capabilities despite outstanding devotion to duty. They can use all the help that industry can offer them. I am certain that significant contributions will result from the very fine Symposium in San Diego. The Navy stands ready to cooperate in such mutually beneficial projects at any time.

Please express the above sentiments and my good wishes to your colleagues.

**Arleigh Burke**
**Chief of Naval Operations**

AERO/SPACE ENGINEERING*'s report on the Symposium referred to by Admiral Burke may be found in the IAS News section, p. 25, of this issue.*—ED.

✦ ✦ ✦

### 1959 Index—Coming Up!

■ I, as many of your other readers undoubtedly do, save every copy of AERO/SPACE ENGINEERING. Future reference to your technical articles would be greatly facilitated if a yearly index to the monthly articles were published. If such an index is already available, please advise me; if it isn't, I think that it would be a worthy addition to an already excellent publication.

**William E. DeGrafft, AFIAS**
**Adelphi, Md.**

*Associate Fellow DeGrafft's note is a reminder that while we're busy publishing technical data, we shouldn't refrain from talking about ourselves if reader benefits might accrue. Henceforth, we'll alert readers to watch for items or features that may be valuable, yet still escape notice. Please see the Green Sheet, this issue.*—ED.


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• **INTERNATIONAL ABSTRACTS**—This 16-page insert reviews technical and scientific literature of unusual and immediate value according to current design trends in the aerospace field. Prepared on IBM typewriters, it is turned over to our printer at the last possible minute to insure timeliness.

• **DATELINE WORLD**—This department contains engineering and scientific news and reports from correspondents all over the globe.

• **LETTERS TO THE EDITOR**—It is an open forum for the exchange of engineering ideas relating to missile, rocket, air and spacecraft research, design, and development. *As an IAS member you are invited to contribute.*

• **PROFESSIONAL NEWS**—Our news section is devoted *entirely* to the engineering professions engaged in air, missile, and spacecraft research, development, and operations—and, of course, is widely read by members of the profession throughout the aerospace industry.

***If you have comments or suggestions on any of the above features and departments . . . write to Mr. Allan Bernhardt, Editor. We want to work with YOU in developing tomorrow's news in the aerospace industry.***

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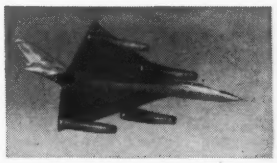

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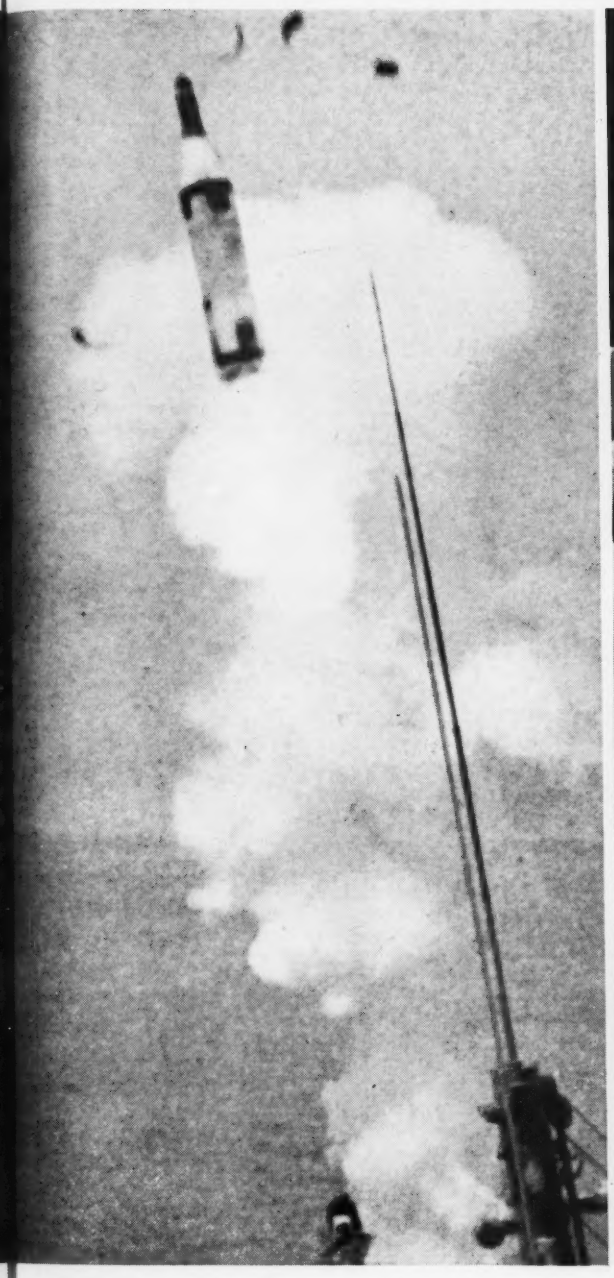
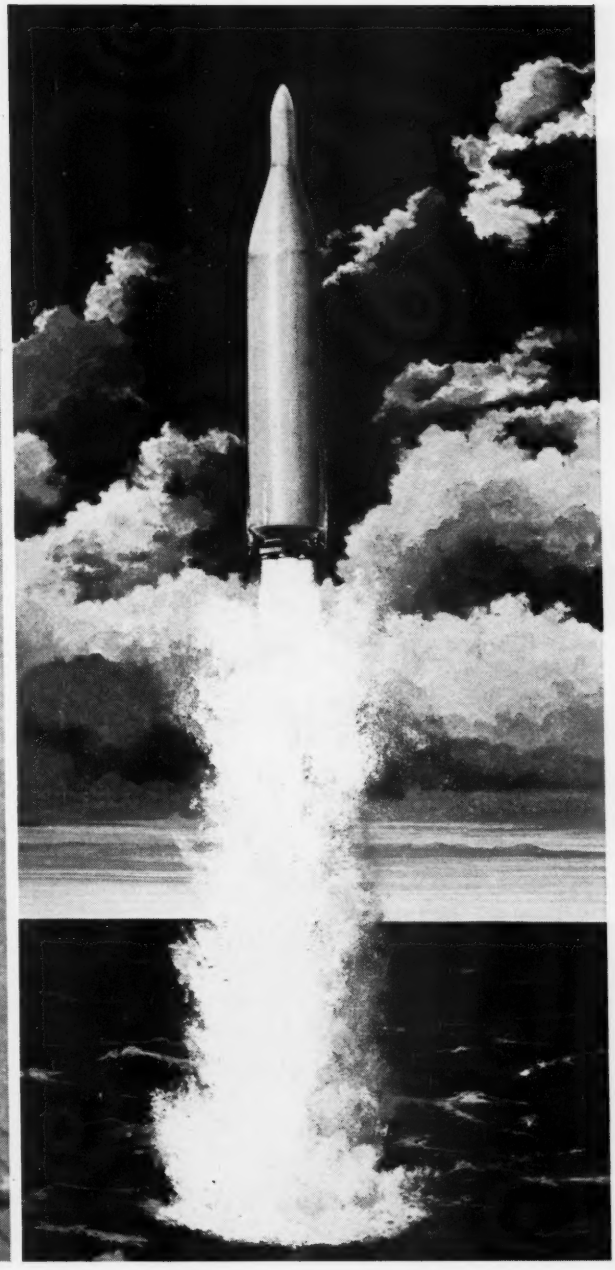
# The Log of the Navy's Polaris

**1958** In January, just a year after the Navy had announced its plan for a Fleet Ballistic Missile, the first Polaris test vehicle was suc cessfully fired. Firings continued throughout 1958. By Septembe the test vehicles were close to the final configuration of the Polari



**1959** Operations Skycatch and Peashooter tested methods for ejecting the Polaris... Operations Pop-up and Fishhook tested a submerged launcher. In August, a Polaris test vehicle was launched from the deck of the USS Observation Island.



**1960** The Polaris is scheduled for active duty in late 1960. Each of the Navy's nuclear subs will carry 16. Lockheed is prime contractor and missile system manager of a team that includes Aerojet-General, General Electric, and Westinghouse.

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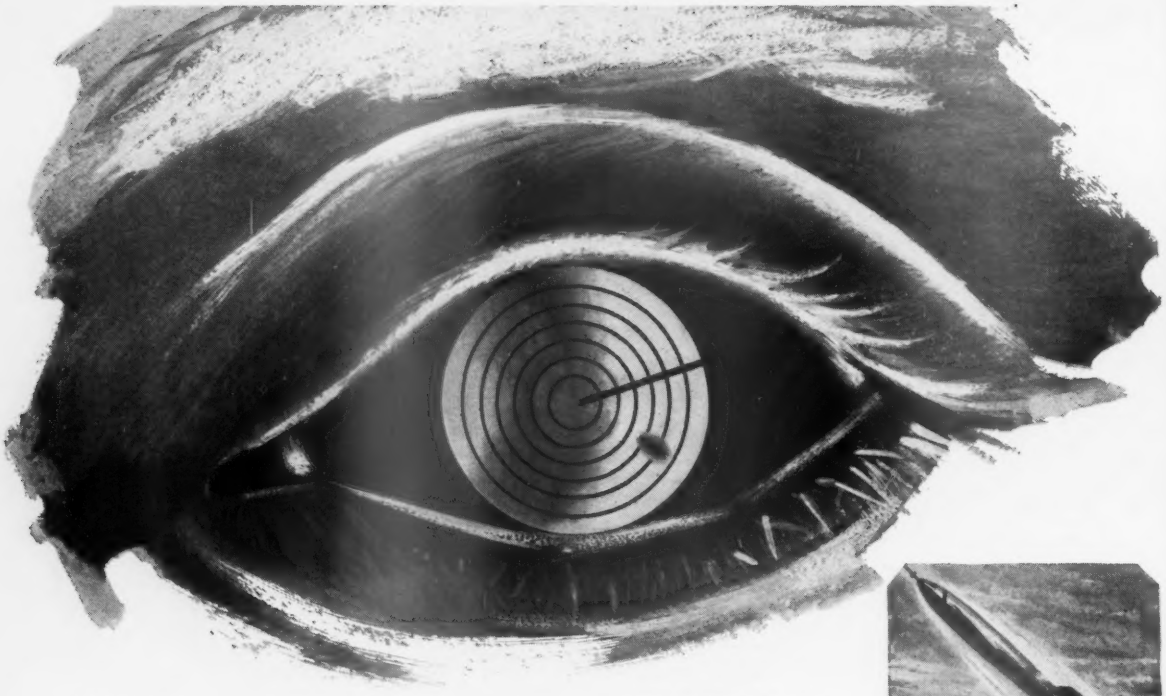

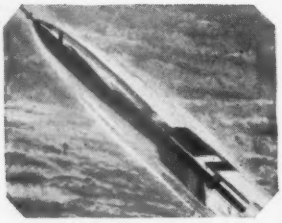

# When a PIP becomes a PICTURE
# *UAP* cools the TV tube!

A new radar tracking system, developed by Sperry Gyroscope, will pick up and track an object at a considerable distance. When the object comes within equipment range, a television camera, developed by Du Mont Laboratories, can pick up the target and show visually its identity.

Cooling and temperature control for the TV Vidicon tube and associated electronic components was assigned to a UAP mechanical refrigeration system. Components are an aluminum plate type condenser and evaporator, semi-hermetically sealed 400 cycle compressor, blower, controls and chassis. The envelope is 14″ dia. x 10″ long, with half the diameter reserved for the tube circuit. Capacity of the 26-pound package is 275 watts at a maximum ambient of 149° F. The UAP system was designed for shipboard application and to meet necessary MIL environmental requirements.

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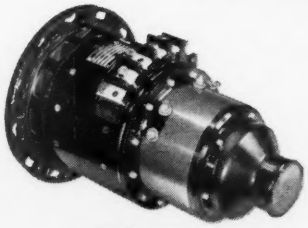
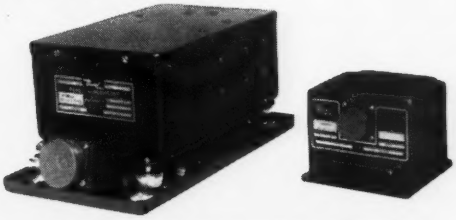


AC Generators



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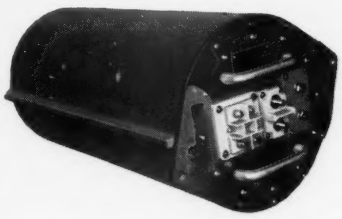

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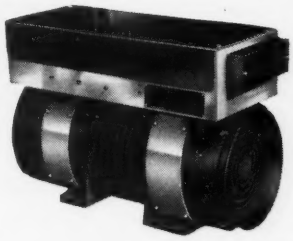

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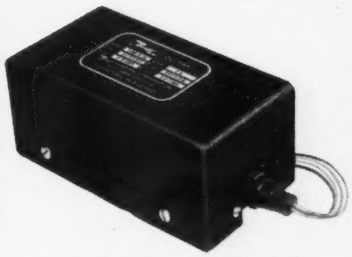

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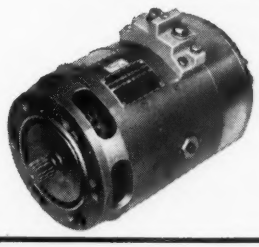

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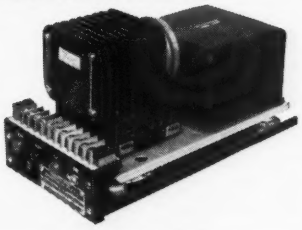

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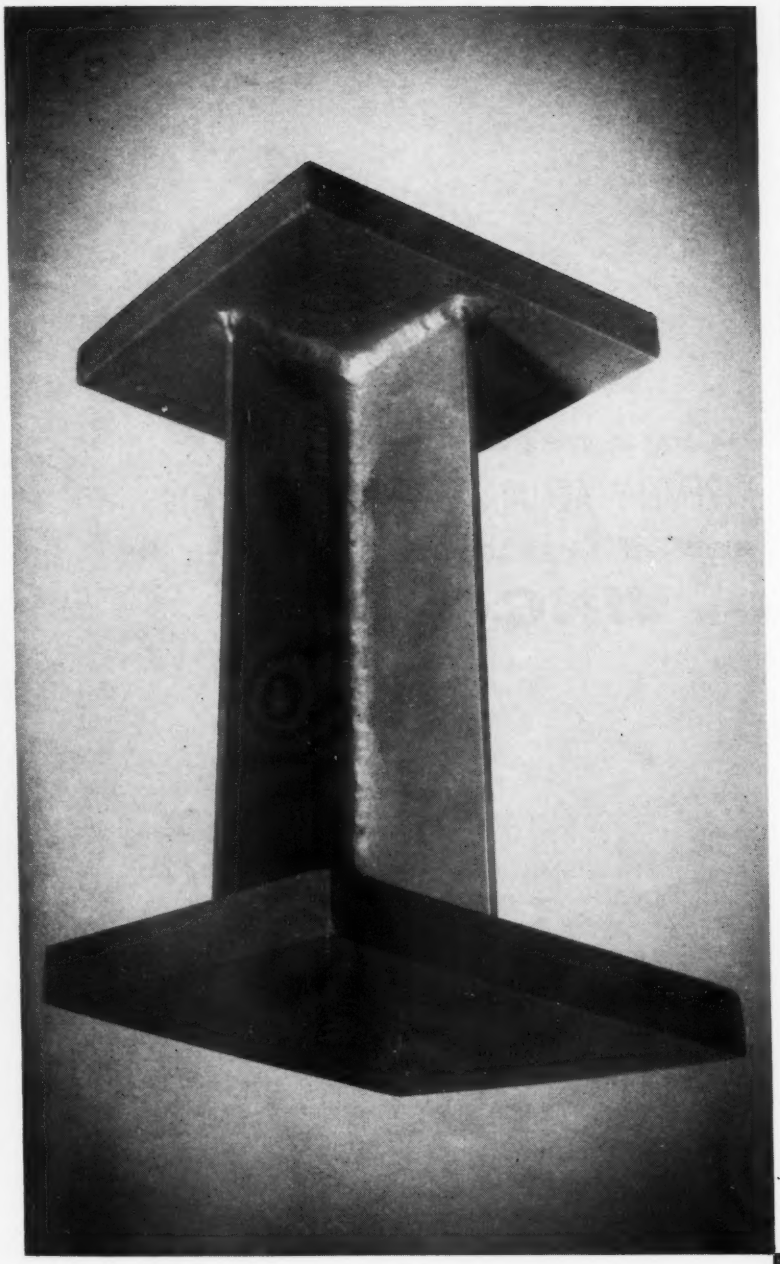

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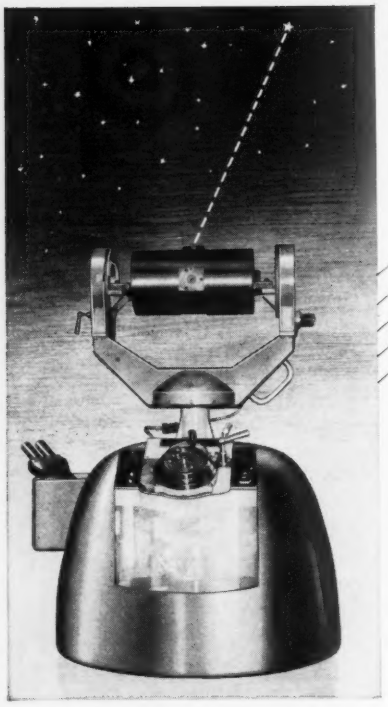

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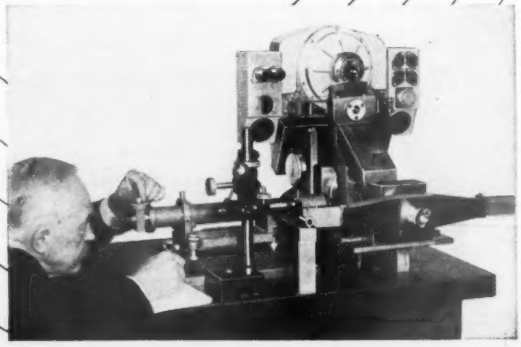

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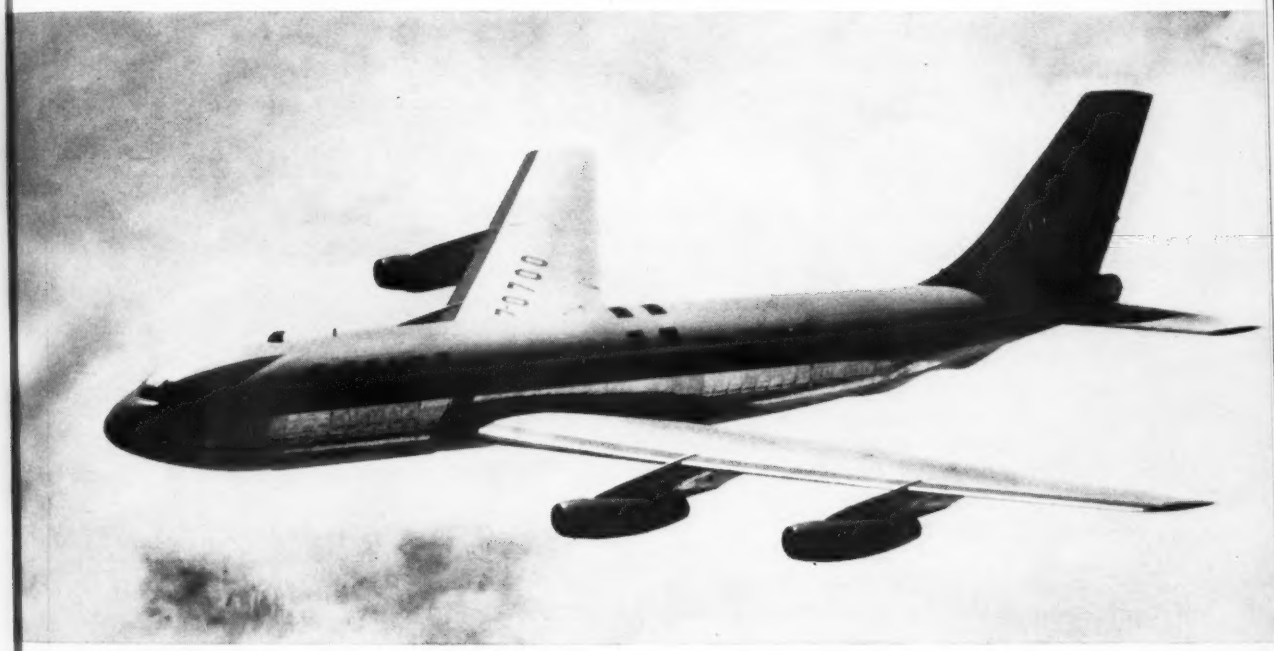


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**3.** Every type of Tiger Brand Control Cable is designed for specific applications. You get the *right* cable for the job.

**4.** They are made by *one* company, U. S. Steel, and every step of production, from ore to finished product, is carefully controlled and supervised to guarantee *one* high standard of quality.

**5.** Tiger Brand Control Cables are manufactured by the largest single producer in the country.

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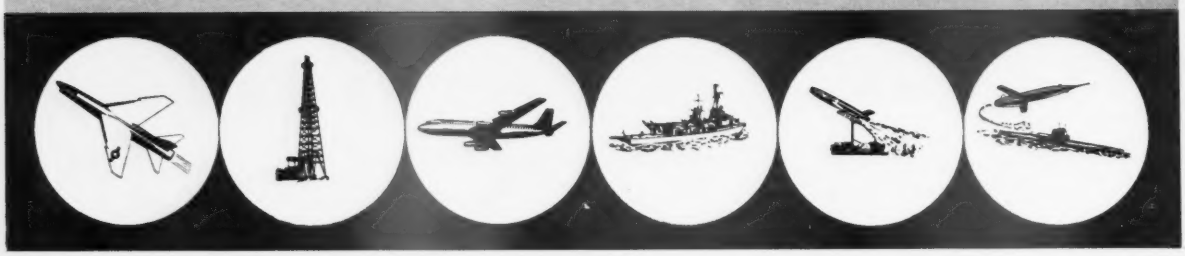

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*– U.S. Supreme Court*




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IAS BULLETINS AND LATE NEWS . . .

November 1959

ALLEN W. DULLES, DIRECTOR, UNITED STATES CENTRAL INTELLIGENCE AGENCY, IS TO BE HONORS NIGHT DINNER SPEAKER AT THE IAS 28TH ANNUAL MEETING, JAN. 25-28, AT NEW YORK CITY'S HOTEL ASTOR. A VETERAN OF THE OSS, AND FORMER HEAD OF A GROUP WHICH SURVEYED THE U.S. INTELLIGENCE SYSTEM IN THE LATE 40'S, MR. DULLES HAS BEEN CIA DIRECTOR SINCE 1953. (ANNUAL MEETING PLANS ARE TO BE REPORTED IN A/SE NEXT MONTH.)

TWO ADDITIONAL IAS EVENTS for next year have increased the number of international and national meetings for 1960 to eight. A National Specialist Meeting on GUIDANCE OF AEROSPACE VEHICLES will be held in Boston May 25-27. Abstracts of about 300 words (sessions classified through Secret are planned) should be forwarded to: Dr. William B. Bryant, of the Boston Section, Program Committee Chairman, c/o Allied Research Associates, Inc., at 43 Leon Street, Boston 15, Mass., by the end of next month. Scope of the meeting will include all phases of attitude and flight path control of aerospace vehicles -- GEV's and S/VTOL types, ballistic missiles, satellites, lunar probes etc. Interested companies and individuals are invited to consider preparation of papers. A SYMPOSIUM ON HYPERVELOCITY TECHNIQUES has been scheduled for October 20-21; committees are being formed by the Rocky Mountain Section and Denver is the city. Additional details will be published in A/SE as announced.

THE IAS FOREIGN HONORARY FELLOW FOR 1958, Sir George Edwards, of Great Britain, has been elected to receive the Daniel Guggenheim Medal for 1959. One of international aviation's most renowned designers and administrators, and Managing Director of Vickers-Armstrongs (Aircraft) Ltd., the Britisher is to be honored at ceremonies in April. The Board of Award cited him for "a lifetime devoted to the design of military and commercial aircraft culminating in the successful introduction into world-wide commercial service of the first turbine powered propeller-driven aircraft." ( Reference is to the Viscount. ) The ASME, SAE, and IAS sponsor the Daniel Guggenheim Medal.

THE 7TH ANGLO-AMERICAN AERONAUTICAL CONFERENCE, which concluded October 16th, will be treated fully in a subsequent issue of Aero/Space Engineering; readers won't want to miss the photo-story planned. Of immediate interest, however, is the fact that registration for the three days of technical sessions, beginning on October 5th, totaled more than 500. The Conference banquet was attended by 419.

EDITOR'S NOTEBOOK

Meet the Staff returns in this issue of A/SE. In this feature our readers may meet those so important to the everyday operation of IAS services.....IAS members and other subscribers who retain A/SE through the years for reference will not want to miss our year-ender feature next month -- the annual index to technical articles and editorials, listing the former by subject classification, and author(s).

## IAS SECTION MEETINGS CALENDAR

Nov. 3 — San Diego: Technical Meeting, IAS Building, 8 p.m., "Supersonic Transports".

Nov. 4 — Philadelphia: Joint Meeting with and at The Franklin Institute, "Traffic Jam Sky (Aluminum Overcast)" by Capt. A.C. Packard, FAA.

Nov. 5 — Great Salt Lake: Dinner Meeting, Officers' Club Hill AFB, 6:30 p.m., "Problems of Present and Future Air Transportation" by William Littlewood, American Airlines, Inc. and President, IAS.

Nov. 10 — Los Angeles: Specialists Meeting, IAS Building, 8 p.m., "Solar Magnetic Phenomenon" by Prof. Robert Leighton, CIT.

Nov. 17 — Washington: Specialists Meeting, National Academy of Sciences, 8 p.m., "Upper Atmosphere Densities from Satellite Observations" by Dr. Gerhard F. Schilling, NASA.

Nov. 19 — Los Angeles: Dinner Meeting, IAS Building, 7 p.m., "Missions and Roles of NASA" by Dr. Abe Silverstein, NASA.

Nov. 19 — New York: Dinner Meeting, Grumman Aircraft Engrg. Corp., Bethpage, L.I. "A Close Look at the Russian Aviation Industry" by Ralph Alex, Sikorsky Aircraft Div., Social hour, 6:30 p.m.; dinner, 8 p.m.

Nov. 24 — Los Angeles: Specialists Meeting, IAS Building, 8 p.m., "Aerodynamic and Heat Transfer Characteristics of Supersonic Separated Flow Regions" by Prof. Andrew F. Charwat, UCLA.

Nov. 24 — Washington: Dinner Meeting, Occidental Restaurant, 8 p.m., "Operating Experience vs Projected Operating Requirements for Turbojet Transports" by Frank Kolk, American Airlines, Inc.

## INTERNATIONAL, NATIONAL AND JOINT MEETINGS CALENDAR

Nov. 2-4 — Midwestern Meeting, "New Frontiers for Aviation", Hotel Lassen, Wichita, Kansas.

Nov. 17-18 — Turbine Powered Air Transportation Meeting, Fairmont Hotel, San Francisco, Calif.

Dec. 17 — Wright Brothers Lecture, Natural History Building Auditorium, Smithsonian Institution, Washington, D.C. (See story page 21 this issue) Lecture to be repeated before Cleveland Section on Dec. 18, Los Angeles Section on Dec. 21 and Texas Section on Dec. 22.

1960

Jan. 25-28 — 28th Annual Meeting, Hotel Astor, Times Square, New York.

Mar. 10-11 — Flight Propulsion Meeting (Classified), Cleveland, Ohio.

Apr. 20-22 — Symposium on Manned Space Stations (cosponsored by NASA and The RAND Corp.), Ambassador Hotel, Los Angeles, Calif.

May 25-27 — Specialists Meeting, Guidance of Aerospace Vehicles, Boston, Mass.

June 27-30 — Summer Meeting, Ambassador Hotel, Los Angeles, Calif.

Sept. 12-16 — 2nd International Congress, International Council of the Aeronautical Sciences, Zurich, Switzerland.

Oct. 3-5 — Midwestern Conference on Air Logistics, Tulsa, Okla.

Oct. 20-21 — Symposium on Hypervelocity Techniques, Denver, Colorado.

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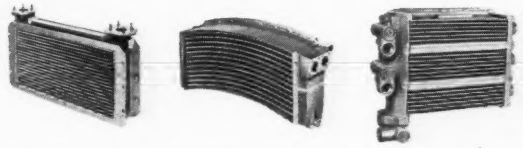

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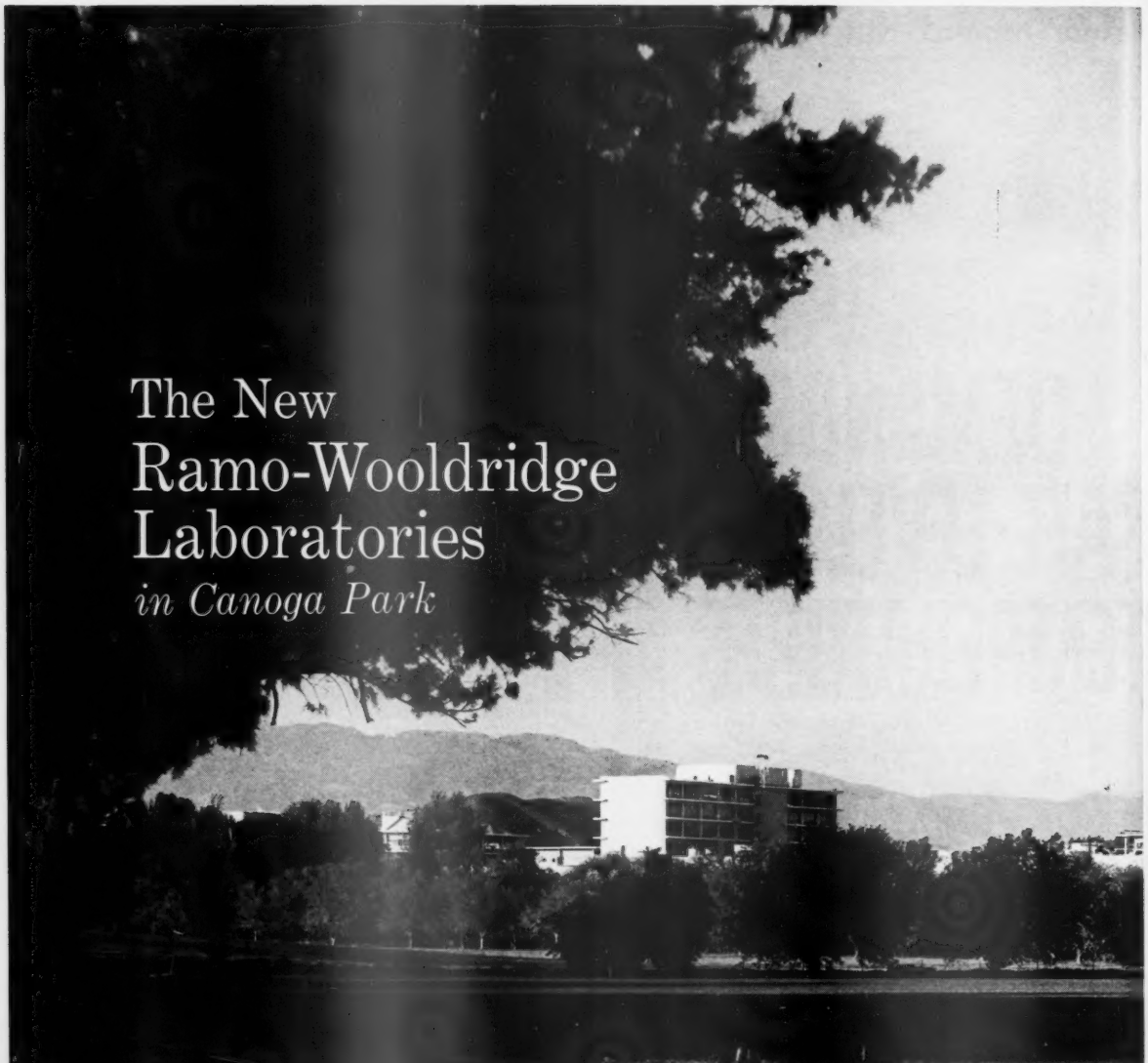


The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

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The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

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IAS News

. . . a record of people and events of interest to Institute Members

# USAF Chief Scientist to Deliver 23rd Wright Brothers Lecture

## *Dr. Alexander H. Flax to Report on High-Temperature Hypersonic Flows in Washington, December 17*

DR. ALEXANDER A. FLAX, 38-year old aerodynamicist, who was recently named Chief Scientist of the Air Force, will deliver the Wright Brothers Lecture, December 17, in the Natural History Building Auditorium, Smithsonian Institution, Washington, D.C.

Dr. Flax's topic will be "High Temperatures in Hypersonic Flow—Physical Principles and Experimental Techniques."

### Lecture Abstract

In this lecture, twenty-third in a series endowed by the Vernon Lynch Fund, he will present and amplify the following concepts: Flight at hypersonic speed in the atmosphere leads to stagnation temperatures high enough to produce significant physical and chemical effects in air. Dissociation of air molecules into atomic oxygen and nitrogen—and formation of compounds of these two elements—may be encountered, as well as ionization and significant thermal radiation from the gas. In addition, the time required for completion of all these processes is in some cases sufficiently large so that true thermodynamic equilibrium is not achieved.

The advance of aerodynamics into this hypersonic, high-temperature regime has had a dual impact. On the one hand, aerodynamicists have begun to face problems in physics and chemistry hitherto outside their domain, and, on the other hand, aerodynamic experiments have become increasingly valuable to physicists and chemists. The extent to which high-temperature gas phenomena are important in many specific hypersonic aerodynamic problems is not yet completely defined. but the broad outlines of the regions in which they may be completely significant are apparent. It is clear that the hypersonic aerodynamicist needs a working knowledge of physical and chemical effects in high-temperature gas flows. At the same time, the experimental facilities and techniques for studying such effects are of basic importance, and many of them are quite different from those which have been used in aerodynamics since its inception.

The basic physical and chemical processes in gases which may occur in high-temperature hypersonic flows will be discussed, and a review will be given of some of the newer experimental techniques which have been found useful in studies of the principal problems. Available experimental data and analytical methods for dealing with high-temperature aerodynamic flows will be summarized, and areas in which further research is needed will be indicated. Finally, the application of the basic principles, analytical methods, experimental techniques, and facilities to the analysis, design, and testing of various hypersonic vehicle types will be considered.

Alexander H. Flax
1959 Wright Brothers Lecturer

### Aeronautical Career

Prior to Dr. Flax's recent appointment to serve as scientific adviser to the Air Force Chief of Staff, he was Vice-President and Technical Director of Cornell Aeronautical Laboratory. He entered the aeronautical field in 1940 as a Structures and Vibration Engineer for the Airplane Division of the Curtiss-Wright Corp. From 1944 to 1947, he was Chief of Aerodynamics and Structures for the Piasecki Helicopter Corp. He joined Cornell Aeronautical Laboratory in 1947 as Assistant Head of the Aero-Mechanics Department and was Head of the Aerodynamic Research Department from 1949 to 1955; in 1956 he was appointed Vice-President for Technical Operations and in 1959 he became Vice-President and Technical Director.

Dr. Flax received a Bachelor's degree in Aeronautical Engineering from New York University, and a Ph.D. in Physics from the University of Buffalo.

### Award Dinner

In 1949 he was recipient of the Lawrence Sperry Award given by the Institute of the Aeronautical Sciences to a young man who has made a notable contribution to the advancement of aeronautics. Dr. Flax was cited "for significant additions to the methods available for determining dynamic behavior of airplanes, helicopters, and missiles."

Dr. Flax is a member of the NASA Advisory Committee on Aircraft Aerodynamics. He is also a member of the Editorial Committee of the IAS JOURNAL OF THE AERO/SPACE SCIENCES.

In addition to being an active participant in IAS activities, he is a member of Sigma Xi, the American Rocket Society, and the American Ordnance Association.

The Marquardt Hyperjet combines both rocket and ramjet in a single, integrated engine system — producing maximum performance from both. It is an engine with controlled rocket thrust for static launch, boost, operation in space and re-entry. It is an engine utilizing the ramjet's superior specific impulse for acceleration and hypersonic cruise within the earth's atmosphere.

From earth to orbit, the Marquardt Hyperjet delivers twice the average specific impulse of today's best rockets, permitting heavier payloads at minimum cost. Yet this same, single propulsion system outperforms any other for hypersonic flight within the atmosphere — shrinks both size and weight of the vehicle required to deliver any given payload.

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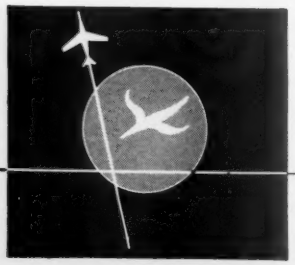

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# IAS-Navy Symposium Attracts 1,000

*Field Trip Goes to Sea as Two Subs, Ten Other Vessels Demonstrate ASW*

Naval leaders, some of the nation's top-ranking scientists, and additional IAS members gathered in San Diego, August 24, 25, and 26 for the IAS-Navy Antisubmarine Warfare Symposium. The primary purpose of the symposium was to present to the Navy and industry a progress report and facilitate an interchange of information on work being done to solve the severe technical problems in antisubmarine warfare.

Much of the credit for this meeting goes to the IAS San Diego Section. Symposium General Chairman was James G. Wenzel, Staff Engineer, Office of the Vice-President—Engineering, Convair-San Diego. Program Chairman A. N. Williams, a Convair engineer, was assisted by Dr. D. A. Wilson, Head, Acoustics Division, U.S. Naval Electronics Laboratory, San Diego. Captain John M. Phelps, Commanding Officer and Director of the Naval Electronics Laboratory, was Honorary General Chairman of the symposium, sponsored jointly by the IAS, the Office of Naval Research, and the Bureau of Aeronautics.

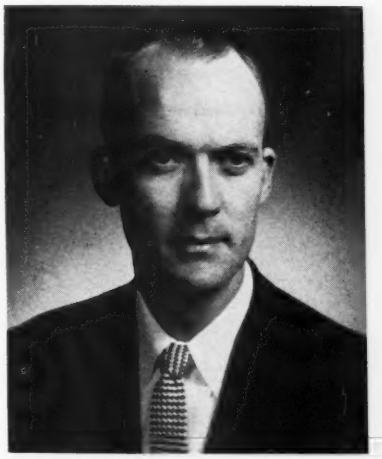
In the first 2-days' Secret technical sessions, over 1,000 registrants heard industry, Government, and institutional leaders outline various aspects of antisubmarine warfare research and analysis under general program headings of "Detection, Localization, and Classification," "ASW Weapons of the Future," and "ASW Operations Analysis and Systems Integration." The keynote address was given by Rear Adm. Howard A. Yeager, ASW Executive of the office of the Chief of Naval Operations.

Speaking at a luncheon meeting on the second day, Adm. Herbert G. Hopwood, Commander in Chief, U.S. Pacific Fleet, disclosed two major organizational changes designed to strengthen defenses against submarine attack. First, Vice Adm. Maurice E. Curts, Commander of the Western Sea Frontier, had been assigned the additional title and function of Commander of Naval Defense Forces, Pacific Fleet, giving him increased responsibility for operational control of fleet units in defense of the West Coast against attack by enemy submarines. "The second major change," he said, "is the establishment of a Deputy Commander in Chief, U.S. Pacific Fleet, for Antimarine Warfare. . . . He will spend all of his time on the ASW problem."

In a talk given at the dinner in the Caribbean Ballroom of the El Cortez Hotel, Adm. J. S. Russell, Vice Chief of Naval Operations, called on the IAS delegation to accept the ASW challenge, saying, "I should like to offer some thoughts on the scope and breadth of the task—that no single type of ship or aircraft, detection device or weapon, is going to be a unique solution. It is, as are so many evolutions at sea, an 'all hands' job." He concluded with the observation that success in solving intricate antisubmarine warfare problems "depends entirely on the skill and determination with which the combined talents and efforts of our scientific, industrial, and military people are applied to the task."

On the third day of the symposium, the delegates boarded the antisubmarine aircraft carrier U.S.S. "Yorktown"; the destroyers U.S.S. "O'Brien," "Walke," "H. E. Hubbard," "H. T. Small," "Prichett," "Cowell," "D. J. Buckley," "Cushing," and "Evans"; and the submarines U.S.S. "Segundo" and "Diodon" for a first-hand look at current Navy Antisubmarine warfare operations.

During the day, twin-engine S2F Trackers of Air Antisubmarine Squadron 23 and helicopters of Antisubmarine Squadron 4 worked hot- and cold-contacts from the carrier. Long-range P5M patrol planes from Patrol Squadron 46 demonstrated long-range search aspects of ASW maneuvers.



General Chairman James G. Wenzel

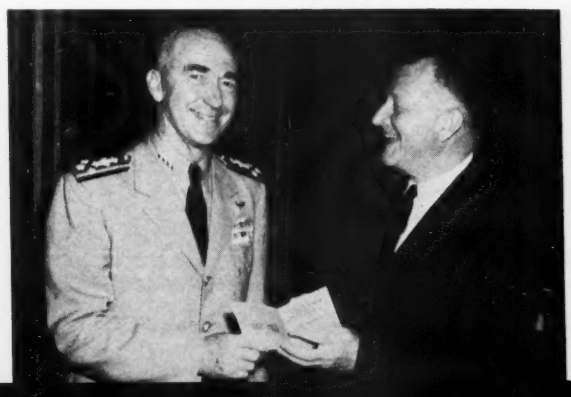
Designed in two phases, the ASW exercises, under the direction of Rear Adm. E. E. Colestock, Commander, Carrier Division Seventeen, simulated a submarine attack on the carrier task force followed by a counterattack by the aircraft and surface force.

These exercises were designed to demonstrate to the IAS observers the Navy's major threat and how difficult it is with present-day equipment and capabilities to thwart this threat successfully. This demonstration clearly pointed out the magnitude of the problem and the need for better technology and equipment to combat the submarine menace.

The at-sea demonstration was controlled from the "Yorktown," Admiral Colestock's flagship, skippered by Capt. L. H. Bauer.

IAS Director S. Paul Johnston shown with Admiral H. G. Hopwood who was guest speaker at August 25 luncheon.

Admiral J. S. Russell and IAS President William Littlewood discussing program before dinner meeting.



XUM

## Report on Durand Conference

Nineteen papers on aeronautics and astronautics were presented by international and national leaders in the field at the Durand Centennial Conference. Held August 5–7, it was sponsored by the Air Force Office of Scientific Research, Office of Naval Research, Office of Ordnance Research, National Science Foundation, IAS, and ASME. The 3-day conference, whose program was listed in the August issue, drew an attendance of over 300.

Chairman of the opening technical session was Lt. Gen. Donald L. Putt, USAF (Ret.), FIAS, President of United Research Corp. In addition to General Putt, there were three Directors of Research of major airplane manufacturing companies. They were George S. Schairer, FIAS, of Boeing Airplane Co.; Dr. Albert E. Lombard, Jr., FIAS, of McDonnell Aircraft Corp.; and Charles L. Critchfield of Convair. The remaining sessions were chaired by Prof. S. A. Schaaf of the University of California, Richard L. Schleicher, MIAS, Chief Structures Engineer, North American Aviation, Inc., and Dr. Milton U. Clauser, FIAS, Director, Aeronautical Research Laboratory, Space Technology Laboratories.

Some 250 participants and their wives attended the conference banquet on August 6 and heard a talk by Willis M. Hawkins, Jr., AFIAS, Assistant General Manager, Lockheed Missiles and Space Division, in which he expressed a fervent belief in man's ability to reach the stars soon. IAS President William Littlewood brought IAS greetings to the conference, and Nicholas J. Hoff, FIAS, Head, Department of Aeronautical Engineering, Stanford University, was Toastmaster.

Grouped outside Cubberley Hall, Stanford University, where technical sessions were held during the Durand Centennial Conference, are (*left to right*) Nicholas J. Hoff, FIAS, Head, Department of Aeronautical Engineering, Stanford; Lt. Gen. Donald L. Putt, USAF (Ret.), FIAS, President, United Research Corp.; E. W. Robischon, Western Region Manager, IAS; Rear Adm. Rawson Bennett, HMIAS, Chief of Naval Research, Department of the Navy; Capt. R. B. McLaughlin; and Smith J. DeFrance, FIAS, Director of NASA's Ames Research Center.

## P. A. Libby Among Planners for International Conference

Paul A. Libby, AFIAS, Professor of Aeronautical Engineering, Polytechnic Institute of Brooklyn, is IAS Representative on the American Conference Committee, 1961 International Heat Transfer Conference, at the University of Colorado, in Boulder, Aug. 28–Sept. 1.

Purpose of the Conference is to make known new fundamental knowledge and practical developments in the heat-transfer field and to bring about an exchange of information between engineers and scientists concerned. The first Conference was held in England in 1951.

Sponsors are The American Society of Mechanical Engineers and the American Institute of Chemical Engineers (U.S.), and the Institution of Mechanical Engineers and the Institution of Chemical Engineers (G.B.). Nine other societies, including the IAS, are participating.

Papers are desired on recent original work or new applications of theory to practice. Abstracts should be sent to S. P. Kezios, Secretary, 1961 International Heat Transfer Conference Committee, c/o The American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N.Y., prior to August 1, 1960.

Several meetings of the Committee have been held; the next is scheduled for the 29th of this month in Atlantic City, N.J.

## GASL Becomes IAS Corporate Member

The General Applied Science Laboratories, Inc., of Hempstead, N. Y., is a new corporate member. The company comprises a group of scientists, engineers, and supporting staff performing advanced research and development in fields relating to aerospace technology such as high-speed aerodynamics, aerothermochemistry, structures, applied physics, and electronics.

Formed over 3 years ago under the leadership of Dr. Theodore von Kármán (HF), the firm now employs about 150 people, with Drs. Lee Arnold (AF), Antonio Ferri (F), and John R. Ragazzini responsible for the technical programs of its various departments. B. J. Driscoll (M) recently joined the firm as General Manager.

Among other projects, GASL has done work in fields of high-speed aerodynamic effects, propulsion system analysis, structural design, aeroelasticity, and digital and analog computer application to simulators and data processing. Its scope of activity covers a broad spectrum from highly theoretical and analytical studies to the construction of prototype equipment employing the latest electronic techniques. The company provides service to a wide cross section of the aviation industry, various Government agencies, and commercial organizations.

## Van Every Is Awarded SAE Wright Brothers Medal

Kermit Van Every, AFIAS, Chief of the Aerodynamics Section of Douglas Aircraft Company's El Segundo Division, was awarded for the second time the Wright Brothers Medal by the Society of Automotive Engineers. It is awarded annually to the author of the best SAE paper on aerodynamics or structural theory or research.

Mr. Van Every's paper on "Design Problems of Very High Speed Flight," which deals with design problems of manned aircraft operating from 1,300 to 25,000 m.p.h., won the award. It covers such topics as flight paths, aerodynamic heating, stability and control, and human effects.

In 1948, he won the Medal for the first time for his paper on "Aerodynamics of High-Speed Airplanes."

# Necrology

## Howard J. Bartleson

The Institute has just learned of the death of Howard J. Bartleson (A) on March 1. He was 32 years of age.

Mr. Bartleson was a Flight Test Engineer with Convair—Astronautics where his duties were primarily flight planning and testing of guided missiles.

He had 6 years of active duty as a pilot in the Navy and had a commercial pilot's license.

He received a B.S. degree in Aeronautical Engineering from the University of Colorado in 1956 and also attended Kansas State College.



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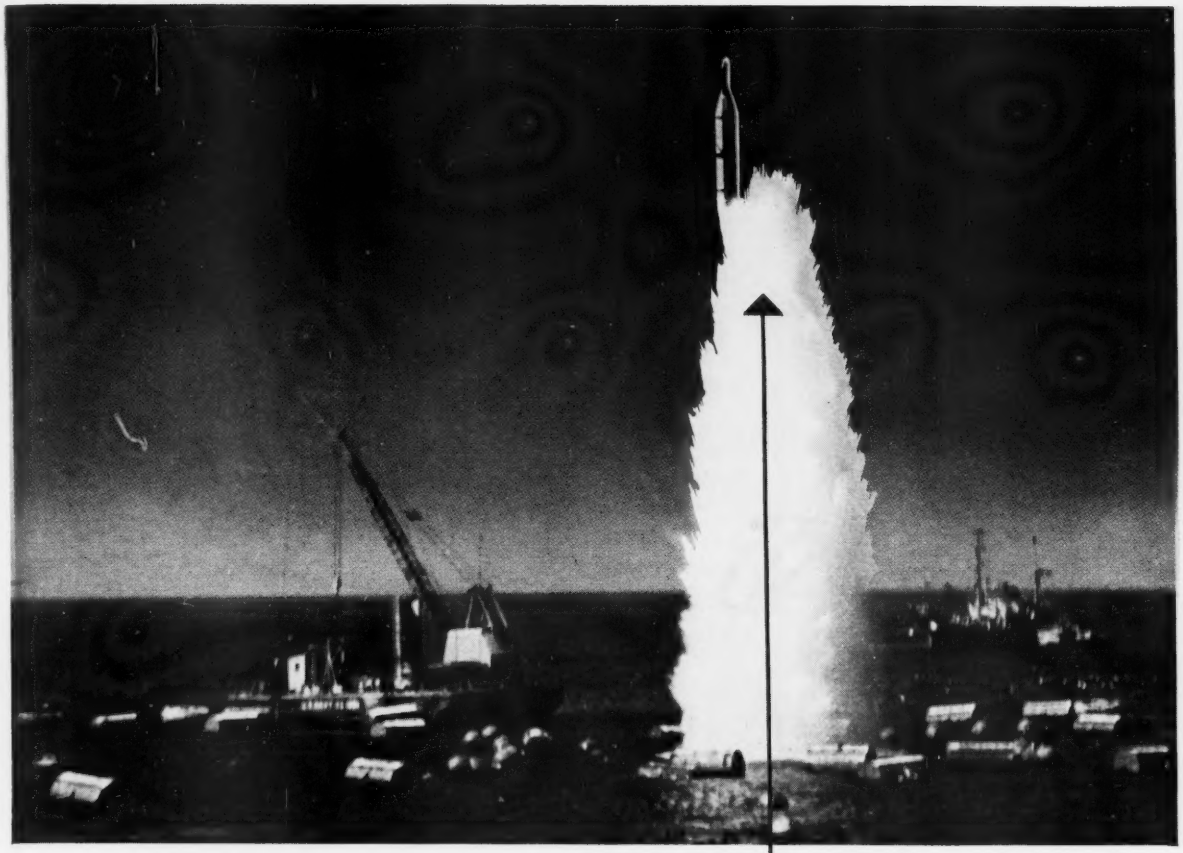


*Official Photograph U. S. Navy*

# TOO LATE FOR TESTING NOW!

**To ensure launching and "in-flight" performance of one of our most important missiles, Barry was asked to study the problems of designing and building a test stand that would simulate the shock and vibration conditions to be met in actual flight.**

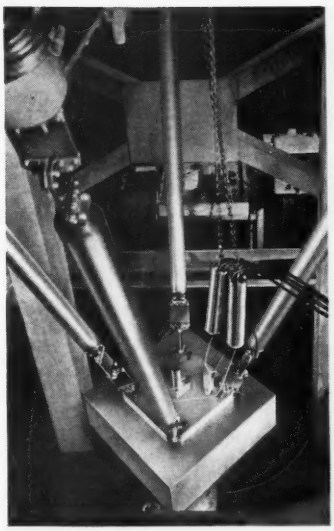
Analysis, feasibility study, ⅓-scale model construction, and test were carried out at the Watertown facility.

RESULT — a servo-controlled mounting system that enabled the test stand to simulate launching and "in-flight" environments. Valid testing – increased reliability were made possible.

Design, development, test, and delivery of prototype system were completed in only five months!

Why not find out how Barry can help YOU?

WRITE FOR *"Engineering for Control of Dynamic Environments"*



DESIGNS THAT CONTROL SHOCK, VIBRATION, NOISE

**BARRY CONTROLS INCORPORATED**

700 Pleasant Street, Watertown 72, Massachusetts

1400 Flower Street, Glendale, California

# Where can you use this versatile HI-SHOCK SWITCH?

Military; missiles, mines, shipboard antennas, or industrial and commercial equipment wherever rigorous vibration, shock or constant acceleration is present, this new Hi-Shock Switch offers distinct advantages.

**Engineered and custom-packaged.** The Hi-Shock Switch can be used for remote power switching (mounted directly on moving members) . . . changeover from primary to auxiliary power source, AC or DC . . . rapid stepping of power distribution.

**Hermetically Sealed.** Use in remotely controlled, power operated units or as a sequence exciter for auxiliary prime movers.

**100% Rotary Action, Counter Balanced.** The actuator, a rotary solenoid, is counter balanced in all axes. Standard coil voltages range from 6 to 48 volts, but other ranges can be furnished as required. High-speed stepping—30 per second—is one feature; higher speeds are available for specific designs.

**Positive Stopping, Positive Locking.** The ratchet mechanism prevents overshooting of the switch contacts—which will not move except during actual stepping. This mechanism is simple, reliable, virtually fatigue-proof.

**Knife-Edge Contacts.** On rotary switch contacts are strong and simple, provide positive connections to prevent chattering under acceleration and other vibration-producting conditions.

**Environmental Ratings.** The Hi-Shock Switch withstands non-operating impacts of 1000 g for one millisecond parallel to its rotating axis, and 100 g for one millisecond perpendicular to its rotating axis. The stepping switch operates under vibration, in three mutually perpendicular axis, of 0.5″ double amplitude 5—17.5 cps., and 10 g 17.5—2000 cps. Constant operating acceleration may be as high as 100 g, in axis parallel to rotation. Operating temperature range may exceed —65°F. and +165°F., and could be extended under special conditions.

Other models also developed with varying configurations and contact arrangements with higher current rating. Write for complete details. *Hi-Shock, Singer Military Products Division, Singer-Bridgeport, 915 Pembroke Street, Bridgeport 8, Conn.* 1999

**SINGER-BRIDGEPORT**
A DIVISION OF THE SINGER MANUFACTURING COMPANY
915 Pembroke Street Bridgeport 8, Conn.

### Gerald E. K. Frayling

Gerald E. K. Frayling (M) died on July 24 at the age of 47.

Mr. Frayling was a Resident Technical Officer at Westland Aircraft Ltd. for the British Ministry of Supply. In 1947 he was the British Supply Office representative at Lockheed Aircraft Corp.

A graduate of Yeovil Technical Institute, England, he was a member of the American Helicopter Society and The Royal Aeronautical Club.

### James B. Humphrey

News of the death of James B. Humphrey (M) on December 30, 1958, has been received by the Institute. He was 43.

Mr. Humphrey was Vice-President and General Manager of Custom Components Switches, Inc., of Burbank, Calif. During his career he has been associated with Lockheed Aircraft Corp., Haskel Engineering & Supply, and more recently the Meletron Corp.

He received a B.A. in Physics from the University of California in 1936.

### Lt. John C. McCoy, USN

Lieutenant John C. McCoy, USN (A), has recently been declared dead by the U.S. Navy after failing to return from a night flight.

Lieutenant McCoy was studying for a graduate degree in Aeronautical Engineering at California Institute of Technology. He was a 1949 graduate of the U.S. Naval Academy with a B.S. degree, and in 1957 received a B.S. degree in Aeronautical Engineering from the U.S. Naval Postgraduate School, Monterey, Calif.

### 1st Lt. William E. Shelton, Jr.

First Lt. William E. Shelton, Jr., USAF (A), was killed in a military aircraft accident on July 9. He was 26 years old.

Lieutenant Shelton was a pilot instructor stationed at Laredo, Tex. Before joining the Air Force, he was an Aeronautical Research Intern at NASA's Langley Field, Virginia.

He was graduated from Virginia Polytechnic Institute in 1955 with a B.S. degree in Aeronautical Engineering.

### Alpheus Holmes Walker, Jr.

The Institute has been notified of the recent death of Alpheus Holmes Walker, Jr. (A). He was 26 years of age.

Mr. Walker was a Structural Flight Test Engineer with Grumman Aircraft Engineering Corp. and had also been associated with the McDonnell Aircraft Corp. as a Junior Aerodynamics Engineer.

He received a B.S. degree in Aeronautical Engineering in 1955 from Boston University.

# Meet the Staff

*An Aero/Space Engineering feature on personnel of the Institute of the Aeronautical Sciences*

## Irene Bogolubsky— *Our "Reviews" Editor*

The extraordinary talents of Miss Irene Bogolubsky as a linguist, translator, and department manager contribute in major degree to one of the primary functions of the Institute—to provide up-to-date and continuing technical information to aerospace engineers through the written word.

Miss Bogolubsky is "Reviews" Editor of AERO/SPACE ENGINEERING, now reaching more than 15,000 IAS graded members and an additional 5,000 nonmember subscribers. Her department, with a staff of three, is responsible for the multipage area of the magazine in which aerospace literature from the four corners of the earth is indexed by subject (Acoustics to Water-Based Aircraft) and published in abstract form. Main subject classifications total 51, but there are 457 secondary and tertiary subdivisions.

These abstracts are found in the black and white pages of *A/SE* just as when this service to readers was begun in January, 1934. A 16-page section of yellow pages also published monthly and identified as International Aeronautical Abstracts constitutes an extension of this research service made possible by contract with the USAF Office of Scientific Research in 1956.

This OSR-supported section, prepared as an insert by Miss Bogolubsky and her staff and reproduced by the photo-offset process, contains data selected specifically for its importance to a great number of engineers for publication sooner than by any other printing method. The 1,300–1,350 items of this insert present a survey (available in no other publication) of the most recent scientific material published in this country and abroad (about 50 per cent foreign), furnishing a longer and more detailed summary of each article than in the non-OSR-supported abstract section.

When Miss Bogolubsky came with the Institute in June, 1955, some 4,000 periodicals and reports were being abstracted each year. The total this year is expected to reach or exceed 8,000. In 1955, abstracts compiled from twelve languages other than English constituted 10 per cent of the total; this year, the percentage will be two and a half times greater.

With a background of formal education in Europe, supplementary study at Columbia University, perfect knowledge of Russian, French, German, and Serbian, and a career in translating technical material, Miss Bogolubsky recently won for her department a rare vote of confidence from *A/SE* readers. This was in the magazine's summer readership survey, in which *A/SE's* abstracts section was declared one of the two "most valuable" areas of the publication.—A.B.

# IAS News — News of Members

**Shepard M. Arkin** (AF) has been appointed to the newly created post of Marketing Manager for the Missile Systems Division of Raytheon Co. He was formerly Manager of the Division's Sparrow III program.

**Jack M. Beauchamp** (A) has, in addition to his duties as Director of Technical Services, been appointed Director, Customer Relations Division, Aerojet-General Corp., with responsibility for all divisional activities throughout the country.

**Paul F. Bikle** (AF), formerly Technical Director of the USAF Flight Test Center, Edwards, Calif., has been appointed Chief of the NASA's High-Speed Flight Station at Edwards.

**Harold A. Cheilek** (M) has been appointed Assistant Technical Director of Cornell Aeronautical Laboratory. He will guide CAL's technical program in the absence of Dr. Alexander H. Flax, Vice-President for Technical Operations, who has accepted a 1-year appointment as Chief Scientist to the Air Force. Mr. Cheilek was formerly Director of the Engineering Sciences Division.

**J. R. Finnimore** (AF), formerly Design Superintendent at British Overseas Airways Corp., has been appointed Aircraft Development Manager.

**Robert W. Kamm** (M), who has been Chief of the Plans and Policy Office at Arnold Engineering Development Center

at Tullahoma, Tenn., has been appointed Director of NASA's Western Operations Office in Santa Monica, Calif. The Western Operations Office resulted from a reorganization of the Western Coordination Office.

**Victor P. Kovacik** (M), formerly Assistant Manager, Advance System Analysis, New Devices Laboratory, Thompson Ramo Wooldridge Products Inc., has been named Research Requirements Manager with the Tapco Group of Thompson Ramo Wooldridge Inc.

**Dr. Hermann H. Kurzweg** (AF), the Naval Ordnance Laboratory's Associate Director for Aeroballistics, represented the U.S. Navy at NATO's 9th annual General Assembly of the Advisory Group for Aeronautical Research and Development (AGARD) in Aachen, Germany, on September 24, 25.

**Delton M. Lundberg** (M) has been appointed West Coast Management Representative, Air Armament Division, Sperry Gyroscope Co. He will be responsible for customer relations, primarily with the military services and aircraft industries. Prior to joining Sperry, Mr. Lundberg was West Coast Representative, Corporate Sales Staff, The Martin Co.

**Richard H. Prewitt** (AF), President of Prewitt Aircraft Co., has announced the acquisition of his company by the Atlantic Research Corp. He will remain President of the Atlantic Research subsidiary.

**R. H. Reichel** (M), formerly of Bell Aircraft Corp., has joined the Boeing Airplane Co. as a Research Specialist in the Aerophysics Branch of the Air/Space Division, Seattle, Wash.

**Thomas B. Rhines** (M) has been promoted to the post of Assistant Engineering Manager at Hamilton Standard, division of United Aircraft Corp. He was formerly Chief Engineer.

Everard M. Lester (AF), formerly General Manager of the Fairchild Engine Division of Fairchild Engine and Airplane Corp., has been appointed Director of Manufacturing of American Machine & Foundry's Government Products Group. Mr. Lester is a member of *A/SE*'s Editorial Advisory Committee, serving on the Flight Propulsion Panel.

**Dr. Martin Schilling** (M) has been named to a newly created corporate staff post of Assistant for Program Planning by Raytheon Co. Dr. Schilling, who joined Raytheon's Missile Systems Division as Program Manager in 1958, served during World War II as a Technical Director of Germany's Peenemünde Research Center.

**S. Michael Treman** (M) has been appointed Manager of Design and Technical Engineering for the Missile Systems Division of Republic Aviation Corp. For the past 6 years, he headed his own company, Treman Electronics and Manufacturing Corp.

**Dr. Everett T. Welmers** (AF), Director of Plans and Programs for Bell Aircraft's Niagara Frontier Division, has been selected to work with the Department of Defense Advanced Research Projects Agency on special space projects. He was granted a 1-year leave of absence from Bell and joined ARPA on September 14. Dr. Welmers was the author of the lead article on "Space Applications for Rocket Vehicles" which appeared in the September issue of *A/SE*.

**Walter C. Williams** (AF), Chief of the NASA's High-Speed Flight Station at Edwards, Calif., has been appointed an Associate Director of Project Mercury. The new assignment will take him to Langley Research Center, Hampton, Va., where NASA's Space Task Group administering Project Mercury is located. He will be responsible for launching command, range, data acquisition, and recovery operations connected with the program.

**Howard M. Wittner** (AF) has been named Project Manager for the communication satellite vehicle project awarded to General Electric's Missile and Space Vehicle Department in Philadelphia. He has been Manager of Advanced Systems Engineering in the same Department.

**Attention Members!**

All Members of the Institute are invited to submit material concerning their activities for publication in the news columns of Aero/Space Engineering.

Dr. John J. Green (F), of Ottawa, who has been the Defence Research Member on the Canadian Joint Staff in Washington, has been appointed Chief Superintendent of the Canadian Armament Research and Development Establishment, Valcartier, Quebec.

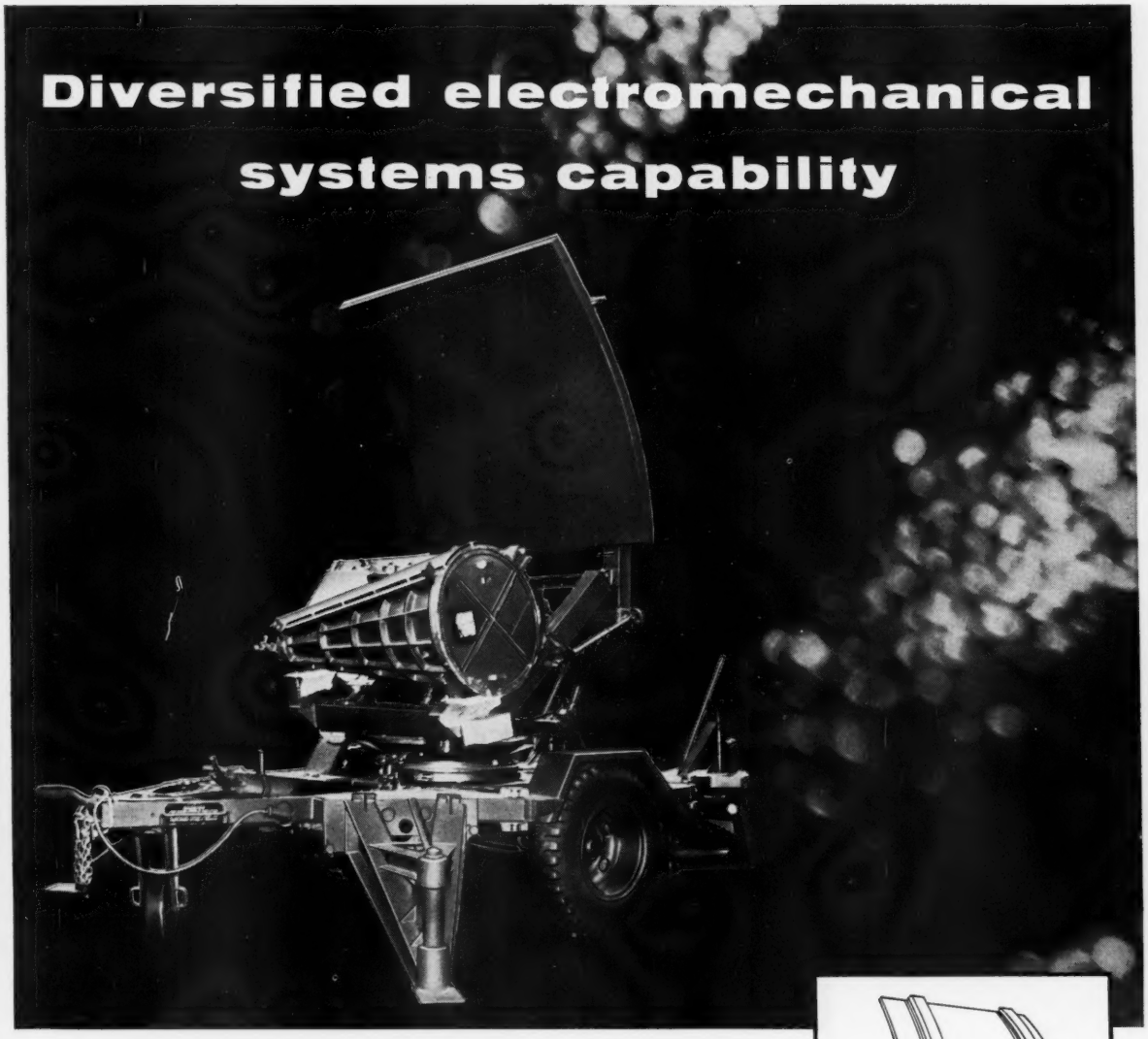
*Nat. Def. Photograph, Canada*

Richard C. Henshaw (AF) has been named Manager of Operations at Lord Manufacturing Co. He assumes overall responsibility for activities of the Engineering, Manufacturing, and Marketing divisions of the company. Starting with the company in 1938, he has held a succession of supervisory and managerial positions.

Robert J. Kirby (M), formerly Manager of the Aerophysics Engineering Operation of General Electric's Missile and Space Vehicle Department, has been named Manager of the Nuclear Ordnance Projects Operation, also in the Missile and Space Vehicle Department. Mr. Kirby is Vice-Chairman of the IAS Boston Section.

XUM

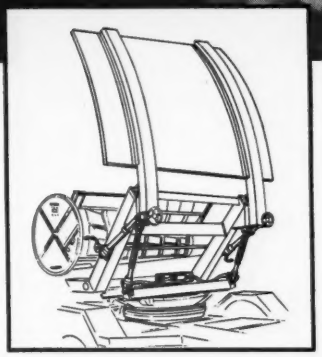
# Diversified electromechanical systems capability



**AiResearch Actuation Systems For Portable Radar** represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.



*U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.*

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

*Los Angeles 45, California • Phoenix, Arizona*

*Systems, Packages and Components for:* AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

# Corporate Member News

• **Aerojet-General Corp.** has entered into a joint agreement with Acoustica Associates, Inc., to explore the application of sonic control to advanced space vehicle programs. The two companies intend to explore practicable methods of utilizing and manufacturing sonic controls for space vehicles. L. M. Limbach has been appointed Corporate Director of Manufacturing; he will direct manufacturing operations in all plants.

• **Aeronca Manufacturing Corp.** has announced formation of an Aerospace Division which will incorporate and greatly augment the company's existing Electronics Research Divison in Baltimore. Clarence G. Felix, Vice-President of Aeronca, will be in charge of the Division, and Dr. Peter A. Castruccio will be Technical Director. J. A. Wascavage has been named Director of Marketing of the new Division.

• **American Airlines, Inc.,** has announced that J. C. Roberts has joined its Properties and Facilities Department as Director, Facilities Construction. Also Robert Kerr, Jr., has been appointed Director, Special Facilities Projects and Administration, and Reginald J. Sutherland has been named Director, Facilities Engineering.

• **American Bosch Arma Corp.** has appointed W. Paul Smith as a company Vice-President.

• **Bendix Aviation Corp.** . . . Cincinnati Division has appointed Edward A. Voss to the post of Manufacturing Manager . . . . Scintilla Division has named Edwin B. Watson Chief Engineer of the Diesel department.

• **Boeing Airplane Co.** has announced consolidation of the Systems Management Office with the Seattle and Pilotless Aircraft divisions into a single unit to be known as the Aero Space Division.

• **Bulova Research and Development Laboratories, Inc.,** has named six new directors to the board: Dr. Theodore K. Steele, Vice-President of Engineering and Research; Oscar B. Brockmeyer, Jr., Vice-President of Engineering Sales; John J. Carpenter, General Manager of Bulova's Electronics and Photographic Divisions; William O. Bennett, Director of Engineering and Research for the parent company Bulova Watch; David C. Stambaugh, Vice-President of Manufacturing for the parent company; and Sol E. Flick, Secretary and General Counsel for both the Laboratories and the parent company.

• **Cornell Aeronautical Laboratory** announced that it will design and build the world's first wind tunnel for long-duration testing of hypersonic missiles and space vehicles under actual atmospheric flight conditions. Funds for the program have been provided by ARPA of the Department of Defense.

• **Garrett Corp.** has appointed Carroll Stoecker as Assistant Manager of its Aero Engineering Division . . . . AiResearch Manufacturing Division of Los Angeles has begun construction of a $2.6 million building, the first building in a new one-million-sq. ft. complex being erected on a 66-acre site in Torrance, Calif.

• **General Dynamics Corp.** . . . Stromberg-Carlson has appointed Dr. Donald G. Wilson as Assistant Vice-President of its Electronics Division.

• **General Precision Equipment Corp.** . . . General Precision Laboratory, Inc., has announced that Col. Bernt Balchen, USAF (Ret.), has joined the planning and requirements staff as an aviation consultant.

• **Lockheed Aircraft Corp.** . . . Georgia Division has appointed William B. Rieke as an Assistant General Manager.

• **The Marquardt Corp.** has established a resident office at Orlando, Fla. The function of the new office will be to provide representation of the company's six divisions and its subsidiary, Cooper Development Corp. Appointed as Manager is U. Wendell Richardson.

• **Meletron Corp.** has announced separation of the company into two individual corporations owned by the same stockholders—the first step in a long-range expansion program. Meletron becomes solely a sales and engineering firm by transferring all production activities to Pressure Switch Corp., a wholly owned subsidiary. Richard L. Shelton, Meletron Comptroller for the past 3 years, becomes Vice-President and Manager of Pressure Switch Corp. George A. Starbird is President of both corporations.

• **North American Aviation, Inc.** . . . Autonetics has named Roy G. Knutson to the post of Manager of Advanced Engineering. . . . Missile Division has named Thomas L. Regan as General Superintendent of Manufacturing.

• **Radio Corp. of America, Defense Electronic Products,** has announced that its five operating units are being raised from departmental to divisional status, with greater autonomy for each. At the same time, they are being aligned under two new group managers: Walter G. Bain who has been appointed Vice-President and General Manager, Communications and Missile Electronics, and Harry R. Wege who has been named Vice-President and General Manager, Missile Surface Radar. Mr. Bain will have overall responsibility for the Airborne Systems Division, the Surface Communications Division, the Missile Electronics & Controls Division, and the 480-L Global Communications Program for the USAF. Mr. Wege will be responsible for the Moorestown, N.J., Missile & Surface Radar Division, and the West Coast Missile & Surface Radar Division, as well as the BMEWS program. Richard E. Posthauer has been appointed Manager of the Washington Office to succeed Mr. Bain, and Irving K. Kessler has been subsequently named General Manager of the Airborne Systems Division.

• **Simmonds Aerocessories, Inc.,** has announced the following appointments: Alex Hossack, Chief Engineer, Product Engineering Division; Eugene Caputo, East Coast Regional Manager, Contracts and Service Division; Harvey Senft, Applications Engineering Manager, Fuel Metering; Robert W. Richardson, Field Engineer in the Detroit office; and Baird W. Hodgkinson, Staff Assistant.



# IAS Sections

## Section Officers Are Elected

Election of new officers for the 1959–1960 season has taken place, and the returns, as listed below, are in from many sections:

**Atlanta Section**—Newly elected officers are Walter Overend, Chairman; A. D. Brown, Vice-Chairman; Hugh Hunter, Secretary; and Thomas B. Woodward, Treasurer. Elected to the Advisory Board are Walter Castles, A. Cleveland, W. Feast, A. Ford, R. Harris, L. Height, and W. Pulver.

**Baltimore Section**—Newly elected officers are Dr. Andrew McCourt, Chairman; W. A. Bortner, Vice-Chairman; Lester Fero, Secretary; and James Bennett, Treasurer. Elected to the Advisory Board for a 2-year term are Dr. Charles Poor, Dr. Stanley Corrsin, Wallace Symington, and W. G. Street. Elected representative to the Nominating Committee for Area Councilors is Ralph Draut.

**Boston Section**—Newly elected officers are Daniel J. Fink, Chairman; J. J. Kirby, Vice-Chairman; Dr. Judson R. Baron, Secretary; and Joseph Bendersky, Treasurer.

**Central Florida Section**—Newly elected officers are D. K. Robertson, Chairman; R. J. Kotowski, Vice-Chairman; K. R. Cossairt, Secretary; and J. A. Roy, Treasurer.

**Cleveland - Akron Section** — Newly elected officers are John C. Evvard, Chairman; Raymond E. Bolz, Vice-Chairman (Cleveland); Carl J. Pennig, Vice-Chairman (Akron); Richard K. Chamberlain, Secretary; and Walter T. Olson, Treasurer. Elected to the Advisory Board are C. M. Bolster, B. T. Lundin, H. F. Powers, W. A. Fleming, J. O. Gibson, F. J. Manganiello, and R. S. Ross.

**Dayton - Cincinnati Section** — Newly elected officers are John S. McCollom, Chairman; David F. Jamison, Vice-Chairman; Joseph Flatt, Secretary; and G. W. Newton, Treasurer. Elected to the Advisory Board are E. Barton Bell,

(*Continued on page 119*)

# He put a new twist in an old trick

His problem was to take a 3"x6"x 3-foot piece of wave guide tubing made of .08-inch thick aluminum and to twist one end 90° to the other *without buckling or stretching any part of it...so that a cross section taken anywhere along its length remained a perfect rectangle.*

The standard solution for a problem like this: Support the tube internally with a solder-like substance that's melted in, cooled, melted out after twisting. It won't work here because the mass of the substance is too great.

Here's how this AMF production engineer found the answer. First, he visualized the concept that, in any symmetrical twist, *the center axis never moves.* Then he applied this concept by stringing a metal rod through the center of 288 rectangular shims, inserted them in the tube, cushioned them with the same solder-like substance. Jaws clamp on either end. One of them rotates *slowly* (twisting time: over 2 minutes) giving the metal time to flow. The result: Perfect twists, every time.

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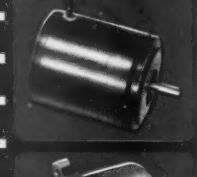

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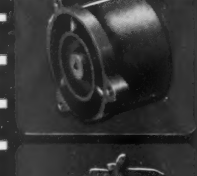

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# DATELINE World

## PROFESSIONAL NOTES AND REPORTS

*Engineering and Scientific Briefs from Correspondents Around the Globe*

### Boost-Glide Flight Popular With U.S.S.R. Writers

◆ "The winged rocket will occupy the intermediate position between the aerodynamic and the ballistic vehicle," says Soviet author A. Shibanov, describing a "ballistic aircraft of the future," in the U.S.S.R. publication *Znaniye-Sila* (*Knowledge Is Power*), 1958, No. 12.

His article is typical of the numerous items on boost-glide aircraft that are appearing in Soviet literature, most of them written in nontechnical style by prominent Russian authors.

After introductory remarks on the need for technological mastery of the upper rarefied layers of the atmosphere, and the progress that has been made in this direction via satellite, rocket, and human-engineering experiments, Shibanov acknowledges the familiar first concern in manned space flight plans—"the assurance of safe re-entry of the vehicle in the dense atmosphere."

At this point, he shows the prevailing Soviet enthusiasm for the boost-glide vehicle. He briefly mentions parachute recovery of experimental rockets as already accomplished, and then goes into detail on the safe-landing aspects of the rocket that will progress from ballistic flight to a gliding flight:

"The ballistic rocket of single action turns into a ballistically gliding rocket plane of multiple action, controlled by the pilot." In the aerodynamic part of the flight, "it is possible to use two methods of free gliding flight . . . the first a ricochet-glide (procedure)," and the second, a steady-state glide "enabling the supersonic glider to remain at its altitude for a long time . . . ."

Shibanov concludes: "The technical difficulties of creating a ballistic-glide rocket aircraft have not yet been overcome. But the great scientific development work in the field of rocket and aircraft technology draws us each day nearer the first start of the ballistic rocket aircraft."

### An-2 Has New Propeller; Better Performance Reported

◆ Russia's An-2 single-engine biplane, used for ambulance service and as a feeder-line transport, has a new propeller, which has square-tipped blades with strengthened root cross sections. Such blades, the designers say, have greater efficiency than saber-shaped blades. Their use decreases the airplane's take-off run 25 per cent and lowers the cylinder-head temperature by 25 deg. The blades have additional bracing bands to prevent cracking along the antifreeze grooves. It is claimed that the new shape of the blades eliminates the overload that appears at the trailing edge of the saber-shaped blades because of the asymmetry of the centrifugal force. The new blade weighs 2 kg. more than the old.

Reportedly, propellers painted white were being tested with a view to reducing heating from the sun and prolonging service life. Whether these tests have resulted in adoption of the white propellers has not been verified.

### Lead Role for Chemistry Seen by Nobel Prize Winner Semyonov

◆ In an article appearing in the *Moscow News*, Nobel Prize winner Nikolai Semyonov states his conviction that, while physics predominated in the first half of the 20th century, in the second half, chemistry will take over. He acknowledges that the physicists still have to face many vital problems—how to obtain controlled thermonuclear reactions, for instance—but believes that chemistry, nonetheless, is responsible "for the present tremendous advance in that very field of technology which has hitherto been the most static and inert —the manufacture of manmade materials."

Synthetic materials are destined to play a paramount part in the development of man's well-being, Semyonov feels, and points out that "Chemistry is making materials which are as strong as steel, as warm as wool, more stable than gold, as elastic as natural rubber, more transparent than glass, and just as beautiful as precious stones." He goes on to say:

"There is a vast field of application for plastics in machine building. I have in mind, for instance, the manufacture of gears and other machine parts which will not require lubrication. Scientists also have to work on the composition and technology of the so-called glass fiber plastics. These are hard, light, and elastic and have a wide range of uses. They may, for instance, be employed to make mine props. Synthetic glass is useful for car bodies and bicycle frames, for furniture, boat bodies, and pylons for high-tension lines.

"One of the most important problems still outstanding is the creation of plastics and synthetic rubbers capable of withstanding high temperatures.

"Opportunities for the use of plastics in construction are indeed tremendous. Strong and easily shaped plastics can be obtained from straw and reeds in those areas which lack forests, while in wooded aresa they can be made from sawdust, molded together with a small proportion of cheap plastic material. The principal task is to commence extensive production of various polymers at an early date and introduce them into every branch of the national economy, into every household. At the same time, a thorough study should be made of other possibilities of using polymers in industry, agriculture, and the home in order to set definite tasks for chemistry and the chemical industry for the creation of new, cheap polymers with the properties required."

### New Calculator Credited With 4,000 Operations/Sec.

◆ According to a Rumanian press item, a new electronic calculating machine, the Raza, constructed by the Institute of Physics and Mathematics of the Belorussian Academy of Sciences, can effect 4,000 arithmetical operations in a second.

The item states that the speed of this machine will exceed by approximately 80 times that of the Soviet electronic calculating machine Ural, first announced in 1955. Extracting the square root, for example, which requires about ten operations on the Ural, is accomplished on the Raza in one operation.

The account of the new machine appeared in the Rumanian newspaper *Scinteia* some time ago.

### 33 Million Pictures/Sec. Claimed Possible With New Camera

◆ An unidentified visitor to Moscow reports seeing on display a camera for the study of high-velocity physical processes which are accompanied by luminescence. It is claimed that the camera can take from 2 to 33 million pictures a second.



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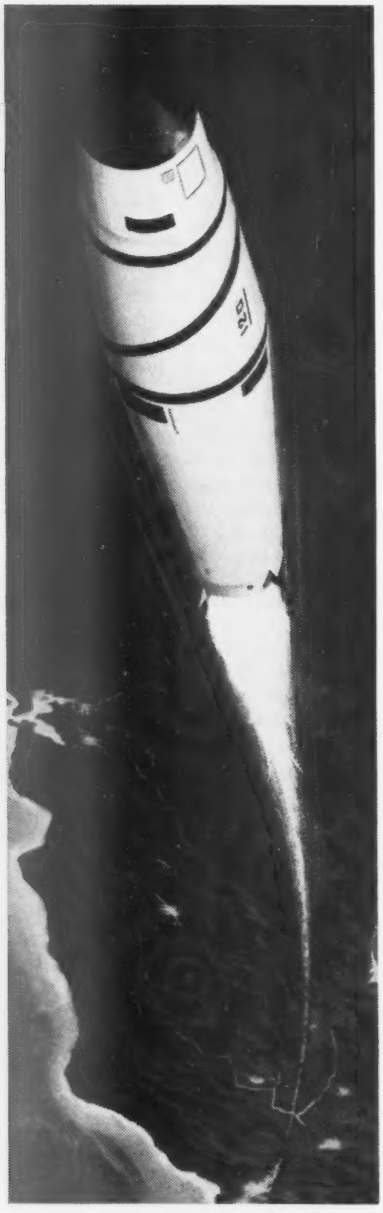
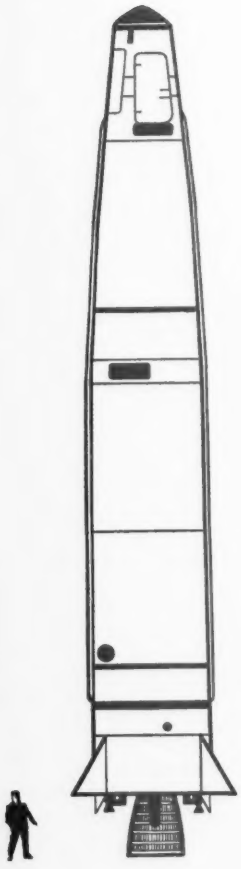


# The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



# The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

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*The Nation's Partner in Defense*

EDITORIAL

# Fait Accompli

The voting membership of the Institute has made its decision regarding the proposed changes in the IAS Constitution and By-Laws which were circulated in mid-July. The result was clear-cut. Over 99 per cent of those who voted checked their ballots for "approval." Almost half of the dissenting ballots were blanks—no vote either way—and the rest were marked in the negative. Of the latter, only a few gave any indication of the reason for disapproval. Most of those who did express opinions took exception to some small detail. No one (of those who added explanations) rejected the plan on principle or *in toto*.

Since, under our original Constitution, change or amendments may be "decided by a majority of the votes cast" (provided that proper notification of such changes has been made to the membership), this qualification has now been met, and the Revised Operational Plan has been officially approved. It may be necessary to go through a few legal formalities at Albany (because we are a nonprofit corporation organized under the laws of the State of New York) to make the wording of our Charter consistent with the exact wording of our new Constitution, but no difficulties are anticipated, and we can now move forward to implement the revised plan.

No one expects that all the changes can be put into effect overnight. The process will be evolutionary. Although there is nothing drastic in the contemplated program, it will take a year or two to put it into final form—longer perhaps before it will be running smoothly.

The new Vice-Presidents, however, should be actual representatives of the several Regions and should begin to function as intended under the Plan during the coming year. This means that the Sections in each region must agree on their nominees between now and the end of November. Since the machinery for such action does not yet exist, the President has written to current Area Councilors suggesting an interim plan whereby the nominees for the first Regional Vice-Presidents may be selected and vacancies on the Council may be filled. It is hoped that meetings of representatives of the several Sections can be held for this purpose. The Western Region has already held preliminary discussions. It is anticipated that the Eastern Region group will meet shortly in Washington and that the Central Region Sections will get together during the mid-Western meeting in Wichita, November 3–4.

It will be one of the most important duties of the new officers to call together the properly designated Advisory Committees of their Regions to develop suitable Standard Operating Procedures for future activities. In setting up the Plan, no attempt was made to codify the detailed rules for the operation of the Regions. It was felt that it would be a mistake to set up any rigid framework and then try to make it fit around widely varying requirements. As time goes on, procedures will be evolved to best suit Regional needs.

The Western Region, which has had the benefit of a regional type of operation for a number of years, has prepared a Standard Operating Procedure based on its own experience. With some modification, this may serve as a model for other Regions. Each must eventually agree upon its own, however, subject only to the limits of national policy and the budget. Copies of this proposal (as modified) have been distributed to the various Section Chairmen for study and suggestion.

We feel that we have evolved, with the advice and assistance of many IAS members, a workable plan to keep all IAS activities in line with member requirements of the future. The basic framework has been set up, but many of the details still remain to be filled in. We bespeak the continued cooperation of every member in helping to work out Operating Procedures that are simple enough to be practical and sufficiently flexible to enable your officers and management to provide programs and publications that fully satisfy the professional needs of the membership in this era of rapidly expanding technology.

S.P.J.

*The method given here involves the determination of the power reflection coefficient at different wavelengths; this coefficient is a function of the number and depth of any layers present and of the electromagnetic constants associated with these layers. Using the mathematical formula for the reflection coefficient of a layered structure, these quantities can be calculated from measured values of the power return at different wavelengths. It is suggested that this experiment be carried out by placing a radar-equipped satellite in orbit around the moon; data on the power reflection coefficient could be telemetered back to earth for analysis. The feasibility of the whole system is discussed.*

# Exploring the Depth of the Surface Layer of the Moon From a Radar Space Observatory

W. E. Fensler, T. B. A. Senior, and K. M. Siegel
The University of Michigan

## (1) Concept

FOR MANY excellent reasons, outer space observations of the moon have been made in the visible spectrum for centuries. During this century, observations have been made of radiation from outer space at many other portions of the spectrum. These measurements include infrared, radar, and radio waves. With the beginning of the space era, space observatories which are uninfluenced by the earth's atmosphere or constrained by the earth's trajectory are now being proposed. It is only natural that the first such space laboratories investigate the moon. It is also to be expected that the instrumentation will be in the visible spectrum. To point out the possible value of investigating the moon by radar is the purpose of this paper, which, while not intended as an exhaustive survey of the benefits of radar for observation in outer space, is intended to give an example of how some information not yet available by other means could be obtained by radar.

Radar can be used to determine not only the heights and contours of mountains and the depths of craters but also how the layer structure varies, as evidenced by a function of permeability $\mu$, permittivity $\epsilon$, and conductivity $s$.

In reference 1 the specular radar return at wavelengths of 0.1 to 2.5 m. are analyzed, and the ratios $\epsilon/\mu$ and $s/\mu$ are determined for the specular areas which are near the center of the moon as seen from the earth. Refined calculations yield

$$\epsilon/\mu = 6.5 \times 10^{-6} \text{ mhos}^2$$
$$s/\mu = 3.5 \times 10^{2} \text{ mhos/henry}$$

A vital question in the case of the moon is where to land on its surface. This question is based on one important "if": If the moon is covered with dust—and the ratios cited above are consistent with some fine sandy particle structures—there will be a danger of sinking when landing. Radar will be able to obtain information about the depth of this outer sandy surface.

This can be done by analyzing a region on the moon at many different frequencies. The depth of electromagnetic penetration will be the order of the wavelength until a more imperfectly conducting material is reached. That is, at some discrete frequency a sharp rise in power reflection coefficient should begin, while at frequencies higher than this the power reflection coefficient should be relatively flat and of order $10^{-4}$ (measurements of the power reflection coefficient in the specular region show a variation of only a factor of two between wavelengths of 0.1 and 2.5 m.). By deriving the ratios of conductivity to permeability and permittivity to permeability, and knowing the wavelength—and thus depth—of occurrence, as well as the width and length of this high-reflection-coefficient region, a basis can be reached for determining the region to land in, or at least for determining a means of selection of a region for further investigation.

Now let us consider how to obtain such a measurement from our radar space laboratory. We want to measure reflection coefficients as a function of frequency for particular areas on the moon's surface. We require a spaceship which will transmit at many frequencies

**This article is revised and updated from a paper of the same title presented at the Fifth Annual Radar Symposium. The University of Michigan, Jan. 27, 1959.**

Mr. Fensler is a Research Engineer in the Radiation Laboratory, Electrical Engineering Department, The University of Michigan. A 1941 graduate of Indiana Technical College, where he received a B.S. degree in Radio Engineering, he took advanced work at the University of Dayton and completed the Air Command and Staff School Course, Air University Extension. From 1945 until 1958 he was a civilian engineer with the USAF, in electronics, guided missiles, and astronautics. He has been with the Radiation Laboratory since September, 1958.

Dr. Senior is a Research Mathematician in the Radiation Laboratory, The University of Michigan. He received his M.Sc. degree from Victoria University, Manchester, England, in 1950 (Mathematics Research) and his Ph.D. degree from Cambridge University (Research) in 1954. He was appointed an Established Scientific Officer with the British Ministry of Supply in 1952 and accepted a position at the facility now known as the Royal Radar Establishment, Malvern, being promoted to Senior Scientific Officer in 1955. He has been with the Radiation Laboratory since June, 1957.

Professor of Electrical Engineering at The University of Michigan, Dr. Siegel also heads the Radiation Laboratory at the University. Holder of many academic honors, he is perhaps best known for his work in physics and mathematics. He is a member of the Finder's List, National Science Foundation, Scientific Advisory Board of the USAF, and Consultant to the U.S. Army and ARPA, and several other organizations and professional societies. His full-time work at the University began in 1948 in the Upper Atmosphere Physics Group of the Engineering Research Institute, which he later headed. Subsequently, he was placed in charge of the Theory and Analysis Department at the Institute and became Head of the Radiation Laboratory on January 1, 1957.

simultaneously. In our example in Section 2 we have chosen ten frequencies. We want to "look" at the same or almost the same area of the moon's surface at each frequency. In Section 2 we show how this can be done with off-the-shelf items.

Little or no energy will be used during data collection since the one thing in space travel that can be obtained for almost nothing is the portion of trajectories where the ship behaves as a satellite; almost circular satellite orbits appear to be the ideal trajectories for collecting depth information by the method briefly described above and described analytically in Section 3.

The earth's ionosphere precludes our getting all the data from a radar on the surface of the earth since long wavelengths are reflected with little or no transmission through the ionosphere.

According to the analysis given in reference 1, there are approximately ten major specular regions on the surface of the moon facing the earth. Our spaceship, of course, will be looking at many aspects that are different from those seen from the earth. The specular region under the spaceship, when it exists, will occasionally be the same as one seen from the earth. On the other hand, there will be other specular regions not near the point on the moon beneath the satellite—in some cases even on the periphery of the line of sight from the satellite to the moon—which could produce other specular returns. However, these regions are easy to resolve by range gating. The key question concerning resolution, as far as the important specular returns are concerned, is associated with the beamwidth of a specular region. There are many types of specular reflections possible. Let us consider only two types here—namely, those in which we get definite focusing or those which involve the radii of curvature of the moon itself. The radar cross section due to the radii of curvature of the moon itself will give us an answer in the order of magnitude of 300 sq.miles. Focusing effects—i.e., flat plate—as well as all other specular effects which are significant in amplitude (such as multiple bounce-corner reflector effects) will vary from pulse to pulse, and on integration we will lose them. This variation is due to the narrow beamwidth of the forward return for all reflectors of significant amplitude. This is precisely what we want because then the only specular region moving with the spaceship itself is the one involving the radii of curvature of the moon. This is what we want to occur in order to determine depth, as we shall see in Section 2.

The space vehicle and radar described in Section 2 represent a compromise in that they are described within current state-of-the-art; in general, one of several possible choices has been made to suggest how the design can be accomplished.

### (2) The Vehicle

The requirements placed on the radar and vehicle are quite stringent. Indeed, they can be met only conceptually for we would require the scanning of a few square feet of area simultaneously by a continuum of frequencies, which is not practically possible since we are limited in size, weight, complexity, and by a vehicle speed of orbital magnitude.

We have chosen an orbital vehicle of practicable dimensions (not much larger and no heavier than Sputnik III), and thus we have placed further limitations on our design. The length is 150 ft.—$^1/_2$-wavelength at the longest wavelength chosen—and the diameter is 6 ft.; the total weight of the orbiting vehicle will be less than 4,000 lbs.

Ten frequencies between 3 and 300 mc. are employed, 1 oscillator, and suitable doublers furnishing the reference frequencies for the final amplifiers. Transmitters feed 1- or $^1/_2$-wavelength radiators, which are spaced around the periphery of the vehicle. To provide scanning (as well as stabilization), the vehicle is spun prior to launching at 300 r.p.m. At an orbital altitude of 100 nautical miles above the moon's surface, and with a pulse repetition rate of 500 pps, each frequency will be pulsed 10 times per cycle—a cycle being a 360° rotation of the vehicle. Since orbital velocity at 100 nautical miles is about 1 nautical miles per sec., the vehicle track on the moon's surface will be about 0.2 nautical mile per cycle.

Although the antennas will provide little resolution, resolution will be provided by the nature of specular

reflection as described in Section 1 of this paper. Because of this specular reflection and the extremely broad antenna pattern, small deviations in vehicle attitude about the yaw and pitch axes can be tolerated.

A means of vehicle stabilization in addition to spinning is required because of the shape of the moon—i.e., deviation from spherical—and other perturbation forces. However, very small reaction forces can be used to achieve this stabilization.

The vehicle will carry a nuclear power source to supply 3 or 4 kw. of electric power. Since this power source will operate at approximately 1,000°F., a considerable amount of energy will be available to operate small jet reactors, while a high-density fluid is carried to become ejected mass. Four such jets will be spaced at 90° around the periphery of the vehicle at each end.

Since only at the highest frequency employed is it practicable to carry antennas of optimum design for the configuration, two 300-mc., 1-wavelength radiators in corner reflectors will be mounted, in line, at opposite ends of the surface of the vehicle, thus separated by about 150 ft. Returns from these antennas will synchronize operation of the vehicle system.

The ten transmitters must be pulsed sequentially at a time when the associated antenna is pointed generally along the gravity vector. To accomplish this, a synchronizer will be activated by minimum-range signals from the 300-mc. antennas. The reaction jets will be activated by error signals resulting from comparison of returns received by these 300-mc. antennas; error signals will result from both range change, indicating pitch, and doppler content dissimilarities, indicating yaw.

In operation, the outputs of the receivers will be integrated over 10 pulses, stored, read out on demand from earth, and transmitted via the 300-mc. transmitter. In order to compare transmitted and received power—i.e., to obtain reflection coefficient—it will be necessary to calibrate the antennas carefully prior to the operation. Power level of the transmitters will be stored and telemetered, along with the associated returns.

The gross weight of the rocket will be about 500,000 lbs.; this assumes an overall payload ratio of 125—i.e., for each pound on orbit, 125 lbs. of "on-the-ground" weight is required (reference 2).

To keep overall length within reason, clustered (parallel) boosters will be used in the first and second stages. With a take-off acceleration of $^1/_2$g, 750,000 lbs. of thrust are required in the first stage. If materials permitting a structural factor of about 0.20 are available, and with fuels of I-specific of the order of 300, it may be feasible to use only three stages; however, four stages would present no unsolvable problems. A burnout velocity of approximately 6 nautical miles per sec. is required; firing eastward from near the equator would, of course, add the earth's rotation speed—about 0.2 nautical miles per sec.

A retrorocket will be used to slow the vehicle to the desired orbital speed upon its arrival at the moon.

**(3) Discussion**

When a smooth homogeneous sphere of arbitrary electromagnetic properties is illuminated by radiation whose wavelength is small with respect to the radius $a$ of the sphere, the leading term in the asymptotic expansion of the radar cross section is

$$\sigma = \pi[ar/(a + r)]^2|R|^2 \quad . \tag{1}$$

where $r$ is the distance of the transmitter and receiver (assumed to be at the same position) from the nearest point on the surface of the sphere, and $|R|^2$ is the power reflection coefficient. The value of $R$ is precisely that which would be obtained by considering reflection from a uniform slab whose electromagnetic constants are the same as for the sphere.

Although Eq. (1) is simple in form, it is an essentially new result, the derivation of which is given in reference 3. When the transmitter and receiver are very near to the surface, so that $r \ll a$, the equation reduces to

$$\sigma = \pi r^2|R|^2 \tag{2}$$

which may be compared with the corresponding result

$$\sigma = 4\pi r^2|R|^2 \tag{3}$$

for a receiver in the near field with plane wave illumination (see reference 4).

To determine the depth of the outer layer of the moon, we first measure the cross section $\pi r^2|R|^2$, and, for sufficiently small wavelength, the reflection coefficient $R$ will depend only on the outer layer. As the wavelength is increased, the effect of the inner layer will be manifested by the presence of oscillations in the curve of reflection coefficient against wavelength; as the wavelength is increased still further, the fact that the constants of the inner layer are, by assumption, large compared with those of the outer means that the inner layer will eventually dominate the return.

The reflection coefficient is therefore measured at a variety of different wavelengths, and from these values the depth and properties of the inner layer are calculated. The experiment will be a complete success when we have determined not only the depth as a function of position on the moon's surface but also the appropriate values (or bounds) for the electromagnetic constants. It should be observed, however, that the constants obtained in reference 1 and the validity of equations such as Eq. (1) above are dependent on using data obtained from specular regions alone.

The theoretical problem to be considered is the reflection coefficient of a two-layered structure. For a "coated" sphere whose outer layer is of depth $d'$, the voltage reflection coefficient $R$ is given by

$$R = (R_1 + R_2e^{2ik_1d'})/(1 + R_1R_2e^{2ik_1d'}) \tag{4}$$

where $R_1$ and $R_2$ are the voltage reflection coefficients of the outer and inner layers, respectively, and $k_1$ is the propagation constant in the outer layer. Another form of the same result, but in terms of the electromagnetic constants, is

$$R = \frac{1-n}{1+n} + \frac{n-m}{n+m}\, e^{i2nd(2\pi/\lambda_0)} \qquad (5)$$

in which*

$$n = \sqrt{\frac{\mu_0\epsilon_1}{\mu_1\epsilon_0}\left(1 + i\,\frac{s_1}{\omega\epsilon_1}\right)}$$

$$m = \sqrt{\frac{\mu_0\epsilon_2}{\mu_2\epsilon_0}\left(1 + i\,\frac{s_2}{\omega\epsilon_2}\right)}$$

$$\frac{1-n}{1+n} = R_1 \quad \text{and} \quad \frac{n-m}{n+m} = R_2$$

In going from Eq. (4) to Eq. (5), the second term in the denominator has been omitted in the belief that this is small compared to unity in the case of the moon, and, in addition, the equation has been expressed in terms of the free-space propagation constant. The other symbols are defined as follows:

$\mu$ = permeability
$\epsilon$ = permittivity
$s$ = conductivity
$\omega = 2\pi \cdot$ frequency

*Subscripts*

0 = free-space
1 = outer layer
2 = inner layer

When $\lambda_0 \gg 4\pi nd$, it is seen from Eq. (5) that, if the properties of the inner layer are such that $s_2 \gg s_1$ and $(\epsilon_2/\mu_2) \gg (\epsilon_1/\mu_1)$, this layer will govern the return. On the other hand, when $\lambda_0 \ll 4\pi nd$, but with the same electromagnetic constants, the very large phase factor will cause the second term (corresponding to the inner layer) to be negligible over any band of frequencies.

As given in Eq. (5), the voltage reflection coefficient depends only on

$$\omega,\ \epsilon_0,\ \mu_0,\ \frac{\epsilon_1}{\mu_1},\ \frac{s_1}{\mu_1},\ \frac{\epsilon_2}{\mu_2},\ \frac{s_2}{\mu_2},\ \text{and } d$$

and since the first three are, of course, known, we are left with five quantities to determine. A possible procedure for the data analysis is to measure the return at five frequencies and hence calculate $d$. In practice it may be best to use additional frequencies and smooth out the minor wiggles by rounding off the measured values. We now have more equations than there are unknowns, and the equations should be tested for consistency.†

The depth $d$ need only be determined when certain conditions are simultaneously satisfied. In the first place, only data indicative of a two-layer structure are considered, and in cases of doubt it is natural to throw away the data. In addition, the fact that we are interested in selecting places to land on the moon implies that the only cases to be analyzed are those in which $d$ is small, with an inner layer having electromagnetic constants characteristic of a hard surface (based on our experiences on mother earth).

For an inner layer of given properties, the smallest $d$ will occur when the smoothed curve of $|R|^2$ against $\lambda$ has its maximum at the smallest wavelength. If, at a particular wavelength, the value of $|R|^2$ is within a factor 10 of unity, the corresponding $d$ can be regarded as minimal, or, alternatively, the wavelength which has been used can be regarded as too large. To decide which of these is correct, a comparison with the data obtained for the same location at a higher frequency should be sufficient.

## (4) Conclusions

In this paper a method is outlined for determining the depth of the surface layer of the moon by radar. Hardware now under development in the United States could be used.

Concerning the exploration of outer space, it is envisioned that space observatories operating in the visible spectrum will work very closely with radar space observatories (possibly using the same vehicle) to obtain the maximum amount of information per space flight.

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* In Eq. (5), $d = (\mu_1/\mu_0)d'$, and from the data in reference 1 it seems reasonable to assume $\mu_1 = \mu_0$. In consequence, no appreciable error should be incurred in regarding $d$ as the depth of the outer layer.

† A further consistency check is to compare the values of $\epsilon_1/\mu_1$ and $s_1/\omega_1$ with those given in reference 1.


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*"In the development and introduction into service of new aircraft, economic timing is important. No matter how superior a design or a growth version of a design might be, unless the economic environment is conducive to acceptance of the particular aircraft, then all efforts will have been in vain."*

# Aircraft Growth

## Local Transport Category

Winfield H. Arata, Jr., AFIAS

Fairchild Engine and Airplane Corporation

HISTORICALLY, most aircraft experience growth. Because of engineering changes, the weight empty of an aircraft will grow during the design stages and after it has been put into operation. Also, during the operational phase, service pickup will add to the weight empty. This is natural as improvements are incorporated in a new airplane, thus permitting it to develop into an economic article with a long and useful life. However, unless the permissible operating weights grow in relation to the weight empty, it is conceivable that a good airplane will soon lose the economic attributes originally designed into it.

Two notable examples of aircraft growth in the transport category are the Lockheed Constellation and the Douglas airline transport series. Previous papers relating to these aircraft (references 1 and 2) have very thoroughly discussed the factors that permit transport growth. Both of these papers are recommended reading for designers and weight engineers interested in analyzing the subject of aircraft growth.

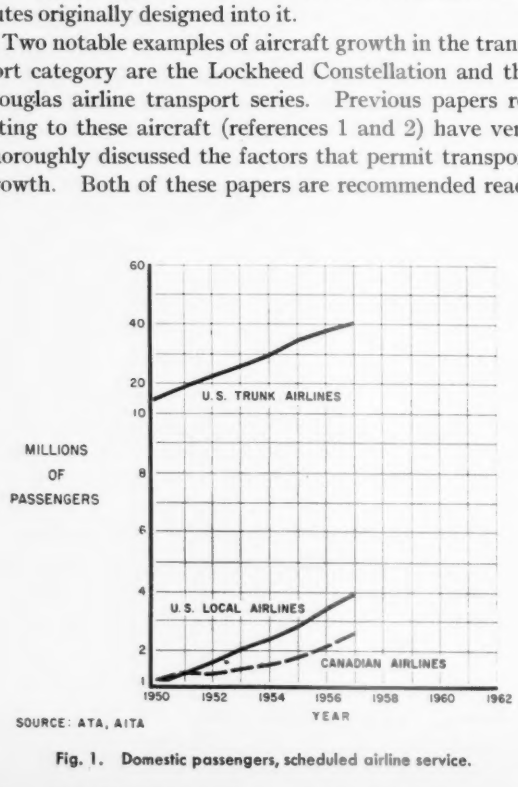


Fig. 1. Domestic passengers, scheduled airline service.

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The purpose of this paper is to discuss aircraft growth in the local transport category. The local airlines themselves have experienced phenomenal growth in the last few years as they service the shorter segments of the air transport market. Fig. 1 shows this growth in relation to United States trunk airlines and Canadian airlines. There is every reason to believe that in years to come the percentage of annual growth will continue to be highest for the local airlines. In selecting new equipment, these airlines must consider a number of factors. Fig. 2 tabulates some of these factors, as well as indicates whether weight is an influence in their decisions. It can be seen that weight is an important factor in analyzing design selection.

### Customer Requirements

As the local airlines have grown in the amount of traffic generated, it has been necessary for them to procure additional revenue-making capacity. Since the trunk airlines are procuring turbojet transports, most of the local airlines are also considering turbine transports. To date, one transport, the prop-jet-powered Fairchild F-27 has gone into service with a number of the local

| PARAMETER | WEIGHT INFLUENCED | USUAL ORDER OF AIRLINE PREFERENCE |
|---|---|---|
| OPERATING COSTS | YES | 1 |
| CRUISE SPEED | YES | 2 |
| USEFUL LOAD CAPABILITY | YES | 3 |
| SELLING PRICE | YES | 4 |
| PRODUCIBILITY & MAINTAINABILITY | YES | 5 |
| COMFORT | YES | 6 |
| STYLE & APPEARANCE | NOT NECESSARILY | 7 |

Fig. 2. Importance of weight.

airlines. This airplane, in addition to offering lower direct operating costs per seat-mile than its predecessor, has actually been generating new markets for the local airlines. Prior to its procurement by each airline, the F-27 was evaluated with competitive aircraft. To provide insight into the airline thinking, the following figures are representative of such an analysis leading to the procurement of new aircraft.

Direct operating costs per seat-mile for various stage lengths are shown in Fig. 3 for two possible 40-passenger aircraft with the same cruising speed—airplane A turboprop, airplane B powered with reciprocating engines. In relating this cost to revenue per seat-mile, it is obvious that airplane A will provide the greater operating profit. It should be noted that indirect operating costs are usually 100 per cent of direct operating costs. Thus the profit potential is a measure of the difference between average fare per seat-mile and total operating cost per seat-mile. The actual amount of profit will be a function of available and actual load factors. Other things being equal, it is believed that passengers are attracted to a turbine transport in preference to a reciprocating-powered transport. Thus airplane A should experience a higher load factor.

Another airline consideration is the number of years that the aircraft will be operated in relation to its (a) depreciation period and (b) reasonable operating life. These considerations in turn are related to the breakeven point wherein the airplane will show a profit in the account books. Fig. 4 is a comparison of airplanes A and B in relation to the breakeven point. It is evident that airplane A provides a more economic justification for purchase than airplane B.

In selecting new equipment, an airline must consider performance with payload capability. When the operating weights are kept constant, it sometimes results in the higher powered, better performing airplane being able to haul smaller payload. However, with the availability of a lightweight, higher rated engine with better sfc's, it could be possible to show a higher speed airplane that would also have a higher payload. It is obvious that power-plant availability plays a large role in the performance and operating weights assigned to a particular aircraft.

## Economic Timing

In the development and introduction into service of new aircraft, economic timing is important. No matter how superior a design or a growth version of a design might be, unless the economic environment is conducive to acceptance of the particular aircraft, then all efforts will have been in vain. First, Government policies as established by Congress, the CAB, and the FAA have a great deal to do with the design and marketing of aircraft. The efforts of Congress, the CAB, the ALTA, and others, in establishing *Public Law 85-307, Air Carrier-Private Loans—Government Guaranty* (reference 3) and *Public Law 85-295, Air Carriers—Equipment Trusts* (reference 4), provided the climate for the local airlines to procure new equipment. These public laws also had a great deal to do with altering the policies of loan institutions, particularly as they have related to the local carriers.

Still another factor relating to the acceptance of new aircraft has to do with the amortization of new equipment. Only by a liberal policy of those concerned will new aircraft be able to operate economically. Thus, in the case of the local carriers, a growing market, enlightened public laws, and the availability of new equipment will all contribute to the growth of this segment of air transportation.

However, this growth will not continue unless the aircraft procured by these carriers permit future growth.

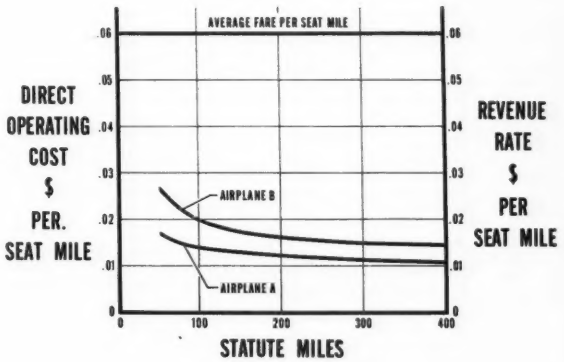


Fig. 3. Economic comparison.

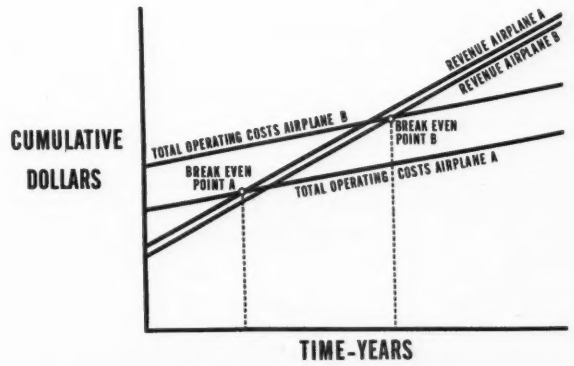


Fig. 4. Economic justification.

Later sections of this paper will elaborate on the growth factors.

### Procurement Regulations

Both the operating capabilities and resulting economic possibilities are directly related to Governmental regulations. In the case of two-engine turbine transports, the applicable regulation is a function of the date the aircraft received its approved type certificate. Fig. 5 shows the take-off flight path definition as applied to two-engine turbine transports. It can be seen that there is a major difference in the flight path and, in turn, in the operating weight capabilities for any given aircraft. Such a variety of regulations makes it difficult for an airframe designer when laying out a new design, especially when Government agencies have been known to make regulations retroactive. If the retroactive feature is not a factor, then the designer can proceed in a knowing manner.

Another factor in designing aircraft relates to the differences between commercial and military operating rules. It must be remembered that military requirements are based upon all engines operating, while commercial requirements are predicated on one-engine-inoperative. The SR-422 series of turbine regulations differentiated between two-engine and four-engine aircraft. To illustrate this aspect of the regulation as related to aircraft design, Fig. 6 has been prepared comparing two 40-passenger transports. Fuel requirements are based on an equal stage length for both airplanes, as well as comparable airport and operating conditions. The total shaft horsepower of the two-engine and four-engine aircraft is considered to be the same for this example. Since the SR-422 regulation is written around the one-engine-out condition, it would be expected that the four-engine aircraft would have a higher permissible take-off weight. However, it turns out that the four-engine aircraft has a lower cruising speed, as well as higher operating costs. Therefore the designer, as well as the potential customer, must closely weigh all factors in determining a new aircraft configuration.

### Compatibility Problems

While an airframe manufacturer would like the luxury of building a single size and type of airframe for all customers, it is not possible if he wants to enjoy a wide market for his product. In the case of the local transport category, four markets are involved—airline passenger, airline cargo, executive, and military. While many components will be common among customers, there are certain changes mandatory to give the customer the best utility for his particular operation. Fig. 7 shows the designer's choice in designing a fuselage for both passenger and cargo operations. If the operator is going to carry passengers during the major part of the operation, and cargo only occasionally, then possibly shoring would be the proper approach. However, with day-in and day-out mixed cargoes, shoring is not desired. This is but one example of the compromises the designer must make in an effort to keep the weight empty to a minimum.

### Component Availability

Component availability is a major factor guiding the airframe designer. In particular, airframe design must be keyed to the availability of power plants. However, as the future unfolds, customer requirements, in addition to the usual engineering parameters, will in-

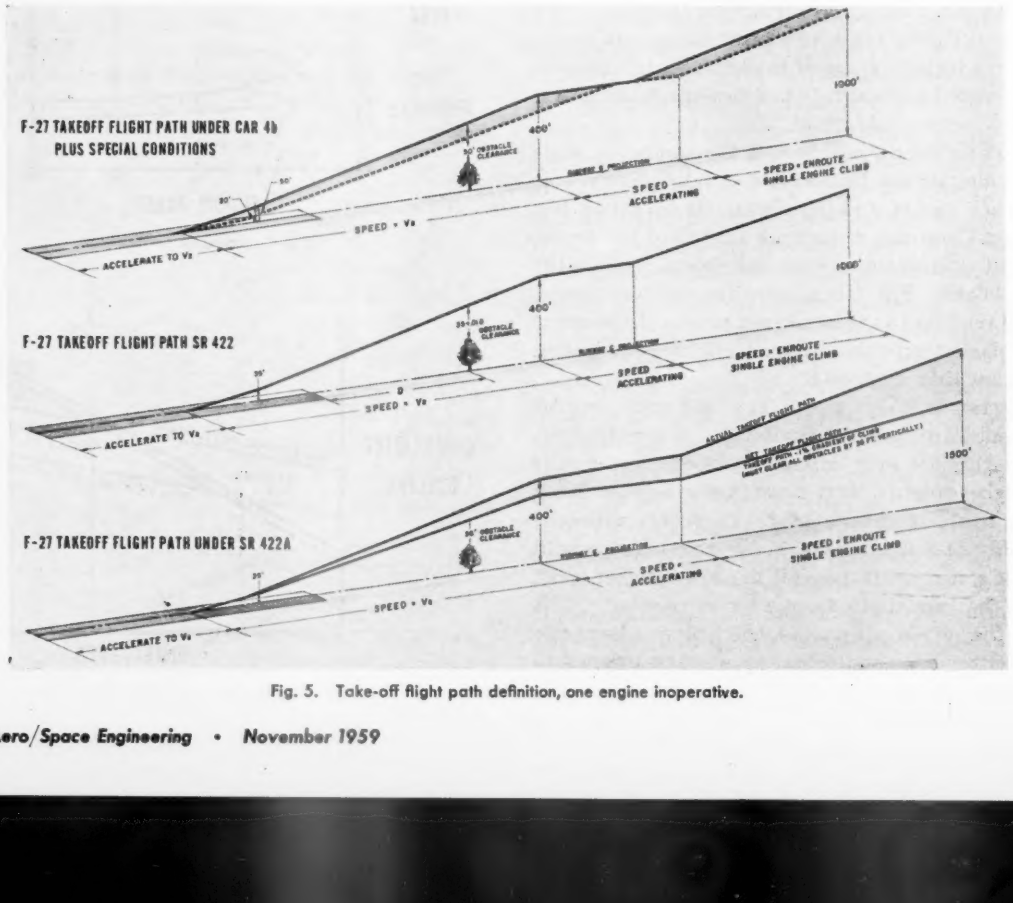


Fig. 5. Take-off flight path definition, one engine inoperative.

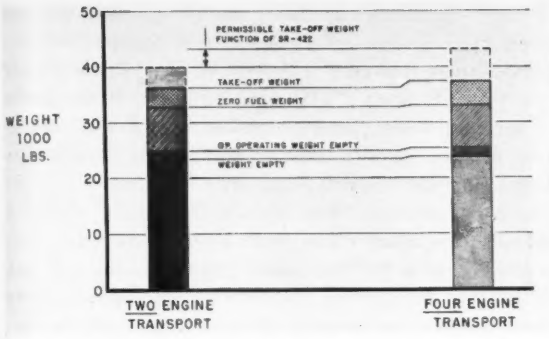


Fig. 6. Regulation influence on design, 40-passenger configurations.

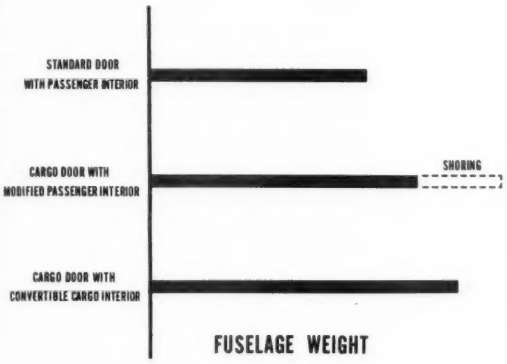


Fig. 7. Combined mission capability.

fluence engine selection. In any case, such factors as specific fuel consumption, reliability—i.e., time between overhaul—engine manufacturers' warranties, and leasing policies sometimes become strong influences. The engine with the most power is not necessarily the optimum selection as economic considerations will usually dictate.

The same analysis can be made for communications and navigation equipment and other components that go to make up a design.

## Design and Weight Relationships

As indicated at the start of this paper, all aircraft experience growth of one sort or another. Fig. 8 shows the tabulated weight growth for a local transport. In the early years of development, this transport had a design landing weight established at 95 per cent of the gross weight. However, because of customer requirements, later models will have a design landing weight closer than 98 per cent of the gross weight. To achieve this operating benefit, it is desirable that the weight empty increase as little as possible. Sometimes these operating increases can be achieved by reanalysis of structural reports, and other times extensive static test programs are involved. The resulting changes to the airframe can be of a minor nature (like increase of bolt diameters), or they can involve extensive changes to the primary structure.

To permit the airframe to grow, as is shown in Fig. 8, it is necessary that the power available to operate the aircraft also grow. In addition to the engine power increasing to match airframe growth as just described, it is desirable that the operating expenses for the engine decrease with time inasmuch as it is the objective of all airframe manufacturers to have subsequent models more economical than their predecessors. In the case of the Dart power plant as used on the F-27, this has happened. The permitted time between overhaul from initial operation in 1953 when the Dart 6 went into operation on the Viscount up to the present time where the Dart 6 is used also on the F-27 shows a continuing increase. Estimated overhaul time indicates that, in the near future, this engine will be capable of operating 2,500 hours between overhaul.

Another measure of airframe growth is ability for the design to permit the carrying of additional passengers or the performance of a different mission. In the case of the F-27, this has been possible. Fig. 9 shows the growth in fuselage size since construction of the first prototype. The first Fairchild production models had a splice added in the fuselage for a standard 40-passenger arrangement, as well as a longer nose to permit the installation of weather radar. For cargo operators, a large 70 ft. by 90 ft. door can be installed in the fuselage. Going beyond the present 36-, 40-, and 44-place versions

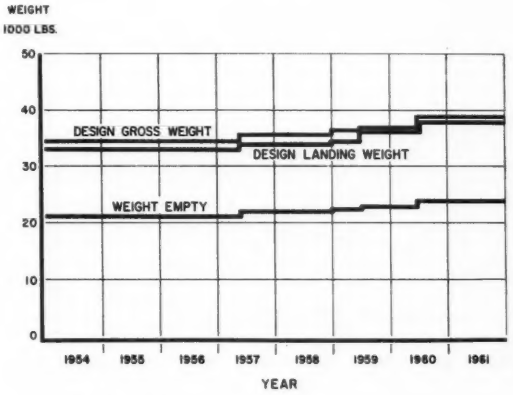


Fig. 8. Weight growth, local transport category.

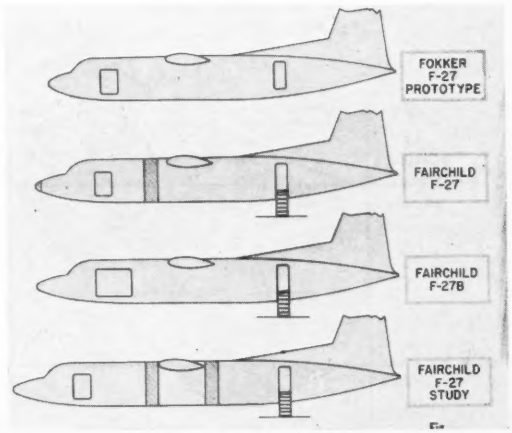


Fig. 9. F-27 fuselage versatility.

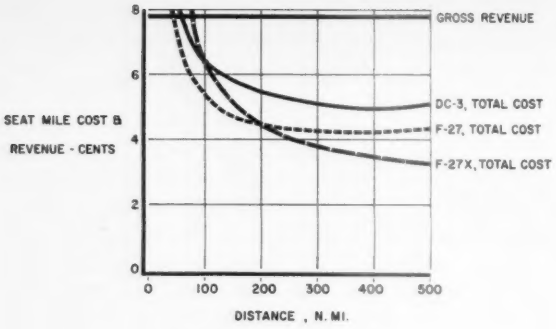


Fig. 10. Purpose of growth.

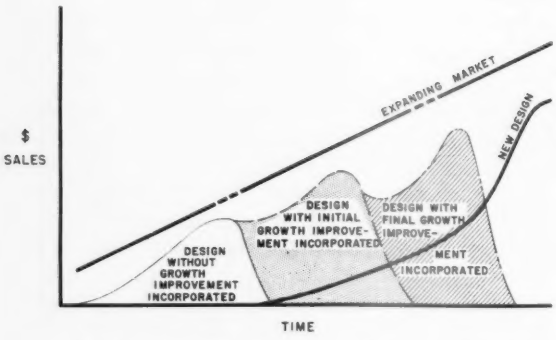


Fig. 11. Market penetration, stretch vs. new design.

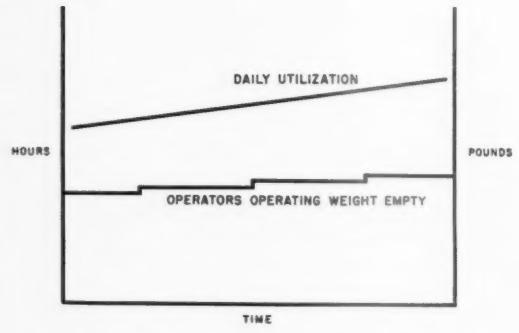


Fig. 12. Operational feedback.

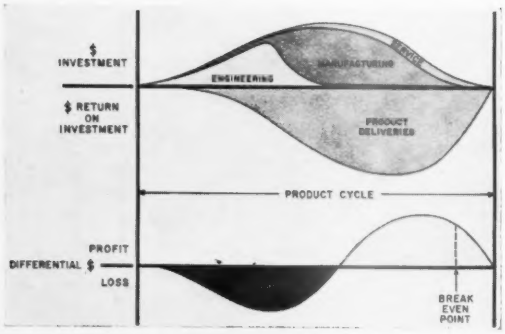


Fig. 13. Product-cost cycle.

of the F-27, studies are being made to permit carrying even more passengers. Also within the present airframe, there has been a growth in fuel capacity. At the present time, a standard airline version carries 1,320 gal. in outer panel integral tanks. For the executive version, bladder cells are added in the center section to increase the total capacity to 1,660 gal. For the recent nonstop ferry delivery of F-27's to the Hawaiian Islands, temporary rubber cells were added in the fuselage—giving a total airplane capacity of 2,320 gal. This ferry installation is preferred over pylon gerry tanks in order not to lose 5 knots cruising speed.

In summary, the purpose of airframe growth is to increase the operational utility of a transport with emphasis on the economic aspects. Fig. 10 measures this desired growth by comparing the DC-3 and F-27 and a future F-27 design. Note that in each case the newer aircraft offers lower seat-mile cost than its predecessor. The direct operating costs shown are usually equal to 100 per cent of the indirect operating costs. Thus the sum of indirect and direct operating costs will give total cost and, when compared to the revenue per seat-mile, will measure the profit potential.

### Stretch vs. New Design

There is a sensitive interrelation between product improvement vs. the introduction of a new design from a timing standpoint. The improvements or new design must not be offered too soon to affect the sales of the present product, but not too late either to lose a part of the market or to have a low spot in factory employment. Also, the stretch design or new design must not come too soon to require the investment of new capital before a reasonable return on the investment from sales of the present product is realized.

In addition, the timing of the introduction of a new design must be keyed to the airlines' ability to absorb a new transport as related to amortizing their previous and present equipment. Also, it must be considered whether the state-of-the-art of the design and major components such as the power plants will be sufficient to interest the airline in making a new purchase. Fig. 11 pictorially attempts to relate how market penetration should be planned. It shows that, up to a point, designs can be stretched with growth improvement to keep up with the expanding market (in this case, the market depicted in Fig. 1). However, there comes a point wherein the costs of improvement are offset by the little improvement in the design features. This is the time when the new design must be ready for marketing.

### Operational Feedback

To provide the proper stretch and growth depicted in Fig. 12, the airframe manufacturer is greatly dependent upon the operational feedback that he receives from his customers. Thus the manufacturer's service department is an important link in this chain of events. By processing the kits of improvements and corrections, the customer has an airplane that will have an adequate

utilization; in fact, a good airplane should grow in daily utilization as time goes by. The modest increases in operating weight empty, as shown in Fig. 12, will be tolerated if airframe and component life is extended to permit the desired higher daily utilization and, in turn, generate more revenue.

### Conclusion

There are many factors—some related, some unrelated—influencing the design and growth of aircraft. Some of the factors, like the Government-guaranteed loans, are unique to the local transport category. Others, like matching power-plant growth to airframe growth, are common to the design of all airplanes; but the one overriding feature of all is that the airframe manufacturer is in business to make a profit. As such, management must carefully guide all departments in order that the resulting profit reflects coordination and control of design scheduling and manpower. Fig. 13 schematically shows the product-cost cycle. The investment in engineering, manufacturing, and service personnel must reflect a return on the investment from sales that will exceed the initial investment. It is usually not until late in the product's cycle that the breakeven point is reached—i.e., where the area of investment equals the areas of return. Obviously, the area beyond the breakeven point is the profit for the entire program.

Thus it can be concluded that aircraft growth is necessary but must be carefully controlled to achieve the desired result for a better airplane wherein both the manufacturer and the operator secure a reasonable profit.

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[4] *Public Law 85-295; 71 Stat. 617, Air Carriers—Equipment Trusts.* An Act to amend section 116 of chapter X of the Federal Bankruptcy Act, to make certain equipment trust provisions applicable to aircraft and equipment of air carriers.


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*"For very accurate measurements of angular accelerations a rate gyro output, filtered and differentiated numerically, will provide excellent results. This implies a marriage of the rate gyroscope and the digital computer."*

# Measurement of Angular Acceleration in Aircraft and Missiles

Howard Stern

Convair—San Diego
A Division of General Dynamics Corporation

An accurate determination of aircraft (or missile) dynamic coefficients (such as the stability derivatives) would simplify many design and flight-test programs, especially if this could be done early enough in the development program. Usually these coefficients are not adequately specified until reams of flight-test data have been analyzed; this generally occurs too late for their optimum use. Two factors have prevented the determination of these coefficients early enough and accurately enough—data reduction processes and instrumentation limitations. The past several years have seen the digital computer take its place as an important flight-test tool. Its proper use alleviates the data reduction problem to the point where instrumentation provides the key to early determination of accurate derivatives.

One of the key measurements for dynamic analysis is that of angular acceleration. This discussion will be limited to the proper techniques of measuring angular acceleration about the pitch axis, since this is usually the most severe case. Measurement requirements will be discussed and defined, but proof that these are realistic requirements will not be given. The requirements have been obtained by discussion with aerodynamicists, dynamicists, and flight-test engineers and are very severe from an instrumentation standpoint.

Formulas for basic instruments such as accelerometers and gyroscopes will be presented here without proof or development. Their application to the particular problem, however, will be given in detail.

### Instrumentation Requirements

Modern high-performance fighter aircraft and high-performance missiles are, in general, poorly damped. The damping which they do is due to two major factors—the horizontal tail surface and the slope of the $C_{L_\alpha}$ curve (static stability). The damping usually depends upon the air density and dynamic pressure and varies from less than 0.1 critical to over 0.3 critical. Airframe response will vary as the damping varies. The response frequency can range from 0.5 to 2 cps on a typical supersonic fighter.

Angular accelerations will be below 1 rad./sec./sec. under virtually all conditions. Detectable load factors can be produced by angular accelerations as low as 1 deg./sec./sec. In order to obtain definitive data, it is estimated that the pitch angular acceleration should be measured to an accuracy of 0.1 deg./sec./sec. for small excursions and 0.3 deg./sec./sec. for large excursions. Since the angular acceleration is usually correlated to some other measurement such as control surface position, it is necessary that the phase angle uncertainty be confined to only one degree. This refers to the range in which aircraft response is possible (0.5 to 2 cps).

The criteria are now established as follows:

| | |
|---|---|
| Full-scale range: | 1 rad./sec./sec. |
| Amplitude accuracy: | 0.1 deg./sec./sec. @ 1 deg./sec./sec. signal to about 0.3 deg./sec./sec. @ 50 deg./sec./sec. |
| Phase uncertainty: | 1 deg. for a 2-cps aircraft oscillation |
| Range of aircraft response: | 0.5 to 2 cps |

The requirements which have been outlined imply several others. In order to have an accuracy of 0.1 deg./sec./sec., it would seem desirable to have a resolution or sensitivity of about 0.01 or 0.02 deg./sec./sec. This is an intuitive requirement based on the assumption that those items which limit sensitivity, such as bearing stiction and pickup resolution, will also affect the accuracy. The theoretical maximum is 0.05 deg./sec./sec. (one half the accuracy).

The phase angle uncertainty is determined by the uncertainty of the damping constant of the instrument. It is extremely difficult to measure the damping to better than 0.1 critical even under laboratory conditions. Under minor temperature changes another 0.1 critical damping uncertainty (plus or minus 0.05) can be expected even with the best of temperature-compensated or temperature-controlled devices. The total

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damping uncertainty is therefore 0.2 critical. This limitation applies to all the instruments which will be considered. In order to fit this uncertainty into our basic requirement, we must obtain an instrument whose natural frequency is high compared to 2 cps so that the effect of a 0.2 damping change is equal to 1 deg. at 2 cps. The following formula holds for this determination:

$$\Delta\psi \cong \tan^{-1}\left[2\Delta\zeta\beta/(1-\beta^2)\right] \text{ (for small } \Delta\psi)$$
$$1^\circ \cong \tan^{-1} 0.4(f/f_n)$$
$$0.0175 \cong 0.4(f/f_n)$$
$$f_n \cong 0.4(2)/0.0175 \cong 45 \text{ cps minimum}$$

where

$\Delta\zeta$ = uncertainty in damping ratio = 0.2
$\beta$ = $\omega/\omega_n = f/f_n$
$\Delta\psi$ = uncertainty in phase angle

### Instruments to Be Considered

We shall consider the following ways of determining the angular acceleration of the system:

(1) A simple angular accelerometer.
(2) A servoed angular accelerometer.
(3) Two displaced linear accelerometers.
(4) The output of a rate gyro differentiated.
(5) The output of a vertical gyro, double differentiated.

It will be shown that the rate gyro approach offers inherent advantages in sensitivity over all other approaches and is capable of meeting the requirements which have been set forth.

During the remainder of this paper the accuracy of the amplitude response will not be considered to any great extent. This is not to say that it is unimportant but rather that the various approaches offer about the same accuracies. In all cases, careful calibrations must be made just prior to the flight if possible. Sensitivity of response to temperature must be known and this factor controlled. In each case, various manufacturers have instruments which are very repeatable under temperature ranges of about 50°F. and which, when carefully calibrated, have accuracies represented by fractions of 1 per cent of the full-scale range.

### Angular Accelerometer

The best devices for measuring angular displacements are inductive devices when extreme sensitivities are required. Microsyns are able to measure angles of about 1 sec. of arc. Some manufacturers claim to be able to measure angles down to about 0.1 sec. of arc, but this figure should be regarded with some suspicion. Now let us uncover the first difficulty:

$$1 \text{ sec. arc} = 0.005 \text{ millirad.} = 0.00028 \text{ deg.}$$

This sensitivity is available to measure 0.02 deg./sec.$^2$ angular acceleration

$$\ddot{\theta}/\Delta\theta = \omega_n^2 = 0.02/0.00028 = 71.5$$
$$\omega_n^2 = 71.5 \qquad \omega_n = 8.6 \text{ rad./sec.}$$

This can be compared with the desired

$$\omega_n = 2\pi(45) \cong 280 \text{ rad./sec.}$$
$$\omega_n \text{ desired}/\omega_n \text{ obtained} = 280/8.6 \cong 32$$

so we are off a factor of 32 in $\omega$, or about 900 in $\omega^2$. Even changing our requirements from a sensitivity of 0.02 deg./sec.$^2$ to 1 deg./sec.$^2$ (factor 50) and accepting the manufacturer's claim of a 0.1 sec. arc sensitivity (factor 10), we are still off in $\omega_n^2$ by a factor of 2:

$$\omega_n^2 = 1/0.000028 = 3.5 \times 10^4$$
$$\omega_n = 190$$

This is 68 per cent of the desired value.

Let us admit now that the initial requirements were established with foreknowledge of what the results would be—namely, that they would appear ridiculous from an accelerometer standpoint. The requirements are probably oversevere by a factor of perhaps 10 to 50, but we will show later that they are achievable with a rate gyroscope.

Suppose we were to accept the watered-down requirements which seem to be possible for a properly designed angular accelerometer—the 190 rad./sec. natural frequency (see Fig. 1). Is this an achievable design requirement?

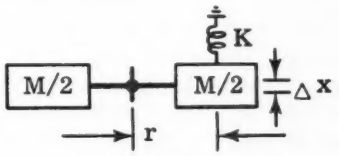


Fig. 1.

$$J = m \cdot r, \quad K = \Delta x/F; \quad \omega_n^2 = K/J$$

for steady acceleration

$J\ddot{\theta}$ = Torque = $F \times r = M \times \ddot{\theta} \times r$
for minimum acceleration $\ddot{\theta}$ = 1 deg./sec.$^2$
minimum displacement = 0.1 in. arc
assume $r$ = 6 in.

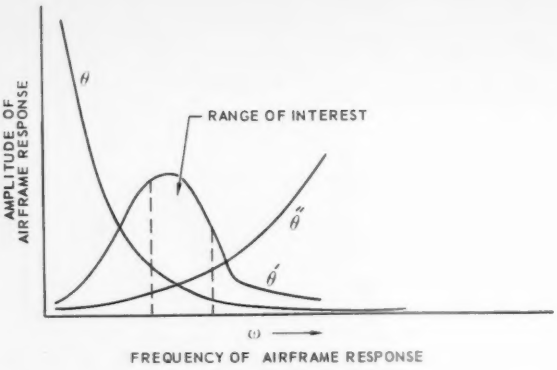


Fig. 2. Comparison of pitch response (displacement, rate, acceleration) as a function of response frequency.

$$F = \frac{W}{g}\frac{1}{57.7} = \frac{W}{(32.2)(57.7)} = 54.2 \times 10^{-5}\ W \text{ lbs.}$$

$$\Delta x = \frac{1}{36{,}000} \times \frac{6}{57.7} = 2.9 \times 10^{-6} \text{ in.}$$

$$K = \frac{\Delta x}{F} = \frac{2.9 \times 10^{-6}}{54.2 \times 10^{-5}} = 5.35 \times 10^{-3}$$

where $J = (W/g)r$, $J = (6/32)W = 0.19W$

$$\omega_n^2 = 35{,}000 = \frac{5.35 \times 10^{-3}}{0.19W^2}\ W^2 =$$

$$\frac{5.35 \times 10^{-3}}{0.19 \times 3.5 \times 10^4} = 80 \times 10^{-8},\ W \cong 9 \times 10^{-4} \text{ lbs.}$$

It is rather obvious that it is not possible to build a device which weighs 9/10,000 of a pound, concentrated at two points 12 in. apart, connected by a rigid, weightless arm. This is why the available angular accelerometers with full-scale ranges of about 1.5 rad./sec./sec. have natural frequencies of 3 cps (19 rad./sec.) and why those accelerometers with natural frequencies in the range we desire (190 rad./sec.) are instruments with full-scale ranges of 100 rad./sec./sec.

### Servoed Angular Accelerometers

Several companies have manufactured small quantities of servoed angular accelerometers. In these units, microsyn-type pickups sense the tendency of the inertial mass to move from its null position. A resultant signal to a servomotor drives the mass back to the null position after a minimum displacement. The servomotor current is proportional to the input acceleration. With this device, the natural frequency is a function of the loop gain so that wide ranges of natural frequency are possible with realistic weights. If an angular accelerometer is used, it must be of this type.

The sensitivity-natural frequency relationship cannot be avoided by going to a servoed system, so the best that can be obtained is a 190 rad./sec. unit which, as we demonstrated before, gives submarginal performance.

The state of the art in servoed angular accelerometers is such that reliable devices are difficult to obtain.

### Two Linear Accelerometers

Suppose we assume that linear displacements can be repeatably obtained in increments of about 0.00001 ft. Using the previously desired natural frequency of 280 rad./sec., we obtain a threshold acceleration as follows:

$$\Delta x = \ddot{x}/\omega_n^2$$

$$\ddot{x} = (280)^2\ 10^{-5} = 0.8 \text{ ft./sec.}^2$$

Acceptable $\ddot{\theta}$ $(\alpha)$ threshold $= 1°/\text{sec.}^2$ max.

$$\alpha r = \ddot{x}$$

$$r/57.3 = 0.8 \qquad r \cong 45 \text{ ft.}$$

This shows that with the outlined accelerometer characteristics, if two linear accelerometers were placed 45 ft. apart, the desired results could be obtained with results superior to those provided by angular accelerometers. Linear accelerometers with the desired characteristics can be obtained, but two factors make their use inadvisable. First, each unit must have full-scale capability to be usable over the entire maneuver range of the aircraft. Since the angular acceleration effects are small, this factor prevents selection of units with optimum full-scale ranges. The second and more important factor is the problem of body bending which will be appreciable at points 45 ft. apart. Since it will be difficult to separate the effects of body bending from the effects of pitching acceleration, this method is best avoided.

### Differentiated Rate Gyro Output

Because of the inertial wheel in a gyroscope, a tremendous gain in sensitivity is obtained. The sensitivity factor is not proportional to $1/\omega_n^2$ but rather to

$$\frac{H}{I_0} \times \frac{1}{\omega_n^2}\left[\frac{\Delta\dot{\theta}}{\Delta\theta} = \frac{H}{I_0} \cdot \frac{1}{\omega_n^2}\right]$$

In currently available gyroscopes the factor $H_{I_0}$ has a range of from 500 to 1,000. $H$ is the spin motor momentum and is equal to its angular velocity times its moment of inertia. $I_0$ is the gimbal moment of inertia.

Gyroscopes with natural frequencies above 45 cps can measure angular velocities of less than 0.01 deg./sec. This indicates that the "blue sky" requirements can be met, provided the output can be differentiated properly. Noise is, of course, the bugaboo of differentiation. Analog filters are not available to filter stray responses without affecting the important data beyond the desirable point. When it is not necessary to make the calculations in real time, a numerical filter and differentiation process such as that described in the General Electric Technical Information Series listed in the bibliography can be used. This filtering method weights each point by points on both sides of it in time. The process gives a tremendously sharp cutoff and results in almost perfect differentiation in the interesting frequency range.

(*Continued on page 62*)

*Man's basic capabilities as a control element—
an actuator, sensor, computer, and a part of a complete control system—
are discussed and conclusions formed as to his strong and weak points
and his possible uses in a space mission.*

# The Pilot's Role in Space Flight

Charles B. Westbrook

Wright Air Development Center

ONE OF THE TOPICS in connection with the field of space technology that can raise heated debate is the role of man in a space vehicle. One school of thought maintains that missions might better be performed with an unmanned vehicle, that man's capabilities under these trying conditions are low, and that he is mostly a disturbing influence. Furthermore, the provisions for his maintenance of life are complicated and heavy and would unduly penalize the boosting rockets.

An opposing school of thought maintains that man has unique capabilities and will be needed, especially in advanced missions in order that the maximum in results can be attained.

Yet another school of thought concedes that the job could be done unmanned, but the curiosity and desire for exploration and exploitation in man will ultimately demand his travel in space, therefore efforts toward that end should be started immediately.

There are numerous other opinions and variations on the above.

It is the purpose of this paper to discuss first man's basic capabilities and then review certain requirements imposed by the mission. The possible uses of man as part of the flight control system of a space vehicle either as a pilot, flight controller, or in another capacity will then be discussed. Certain of the comments, although made with respect to the flight control subsystem, have application to other subsystems.

Throughout this paper, the assumption will be made that the aeromedical problems of man's survival and efficient operation in the space environment can be solved.

## Man's Capabilities

Before beginning a discussion of how man might be used in space, let us consider how he has been used in the past in aerodynamic type vehicles and what his capabilities are.

Man can be considered as composed of three elements, an actuator or motor, a computer, and a sensor system.

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These elements have directly analogous counterparts to certain pieces of equipment in an automatic control system.

Let us look first at man as a motor, actuator, or power source. In the past by careful aerodynamic design, it was possible to use the actuator capabilities of man directly. With the advance in performance of aircraft, it became very difficult to design a system that under all conditions of flight would stay within the envelope of desirable forces. This led to the general adoption of powered controls on our new aircraft. The important point is that the variation in characteristics is responsible for the need for supplementing man as an actuator. It corresponds roughly to the situation on an automobile with power steering; in this case, we must control the vehicle at various speeds and still swivel the low pressure tires for parking. In automobile design, the requirement for power steering is still marginal whereas on the B-58, for example, we need over 200 hp. at full rate and loading to assist the pilot in controlling the elevons. Reference 1 discusses data that is available on the mechanical power output of man. Examination of man shows that we have an actuator device capable of a very wide range, from picking up an egg without damaging it to producing over one horsepower on bicycle pedals or even more in short bursts.

In the early days of flight, the abilities of man as a sensor were largely used, unaided by instruments. His eyes together with computational elements of the brain were used to determine a multitude of information

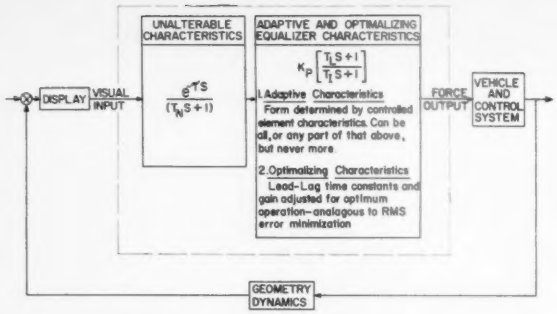
UNALTERABLE CHARACTERISTICS
ADAPTIVE AND OPTIMALIZING EQUALIZER CHARACTERISTICS
DISPLAY
VISUAL INPUT
$\frac{e^{-\tau S}}{(T_N S+1)}$
$K_p\left[\frac{T_L S+1}{T_l S+1}\right]$
1. Adaptive Characteristics
Form determined by controlled element characteristics. Can be all, or any part of that above, but never more.
2. Optimalizing Characteristics
Lead-Lag time constants and gain adjusted for optimum operation—analagous to RMS error minimization
FORCE OUTPUT
VEHICLE AND CONTROL SYSTEM
GEOMETRY DYNAMICS

Fig. 1. Linear model of human pilot.

—for example, positions, rates, and accelerations. His ears were used for auditory signals that were useful in vehicle control. The mechanism in the inner ear assisted then, as now, with signals regarding the balancing and turning of the body; senses of pressure on the skin and tension in the muscles aided in vehicle control. With the development of improved aircraft, there came a vast expansion of instrumentation designed to aid the pilot in the accomplishment of his mission, primarily through the visual sense. Here, as in other aspects, the adaptability of man is found to be his strong point. Better instruments than man can be built to do a particular sensing job over a restricted range. However, to match his ability to perform many sensory tasks over broad ranges is most difficult.

It is said that the individual brain contains 10 billion cells all in certain groupings with some function or other. The capacity of man to compute, make judgments, and determine actions using this brain or computer is now and will be in the foreseeable future the same as it was in the days of the Wright brothers. We all know that we can exceed certain characteristics of the human brain with machines. One example that comes readily to mind is the use of digital computers such as Univac to process mountains of data, solve a formidable equation, and accomplish orders of magnitude faster than man could. However, to duplicate all the capabilities of the human brain for computation and judgment is at this time certainly an impossible task. A question would remain to anyone trying to decide on whether or not a man as a computer should be included on a given space mission. This question would be whether or not this capability could be dispensed with in part or substituted for by human intelligence and judgment on the ground.

Let us now consider man as a part of a complete control system, including his capability as a sensor, actuator, and computer. Fig. 1 shows a block diagram of a linear model of the human operator performing a tracking task. Reference 3 reports on work that has been done to establish a mathematical model of the human pilot. In Fig. 1, the pilot's characteristics have been represented by two categories, those that are relatively unalterable and constant and those that are appropriately adjusted as a function of the particular task. The unalterable characteristics include the neuro-muscular lag $T_N S + 1$ and the reaction time delay $e^{-\tau s}$ which in many practical problems is the most dominant factor.

The form of the equalizer is adapted to one consistent with best performance of the task. For example, the human being can adjust so as to have a pure gain, a gain plus a lead, a gain plus a lag, or the full gain, lead-lag shown. The equalizer also possesses an optimalizing characteristic, such that after the form is fixed the "constants" are adjusted for optimum type of operation in a fashion analogous to minimizing root mean square error. In addition to the capabilities outlined here, which refer to man following unpredictable disturbances, the human being has an ability to recognize patterns. For example, after recognizing a sinusoidal input, he can modify his response to one where there is no error whatsoever. Also, man has the ability to take action on the basis of learning. A good example of this behavior is the complex task performed by a second baseman making a "double play."

Understanding of Fig. 1 is very significant toward understanding man's possibilities in space flight as a control device. The *unalterable* characteristics of man represent his most serious liabilities as a servo element. On the other hand, in the qualities of variable sensitivity, equalizing characteristics, and learning, we see the outstanding abilities of man as a servo system. The capabilities are far beyond what can be built into an autopilot.

The necessity of man to have rest, relaxation, and refreshment is obvious; these needs have been met in the past and will be met in the future in the same way. This will be by providing sufficient crew members or spare crews to perform all required functions and by design and provision of instrumentation and equipment to aid the crew in certain difficult or bothersome conditions.

In considering the use of man in space flight, we must consider the possible changes caused by the space environment on the capabilities discussed above. We might first mention high *g* loadings. These effects have been extensively investigated and man's limitations with various body orientations and protective gear are relatively well known. These effects may be important in the exiting phase and in ballistic and low lift re-entry. The effect of zero *g* on man in space flight is almost unknown, however. From the meager evidence from flight tests on aircraft in zero *g* trajectories, there is no evidence that man will be seriously affected. Certainly one of the objectives of our initial manned space vehicle programs should be to test man's control and judgment capability under this zero *g* environment.

Many other factors may adversely affect man such as temperature, confinement, no visual references, odors, noise, etc. Many of these problems can be alleviated, at least in part, at the cost of additional vehicle weight. It will be the space designer's job to determine the minimum weight that he must provide to alleviate a given problem.

Let us now summarize man's main drawbacks and attributes as a flight control component. Man has

certain physical limitations which are a drawback in certain cases. He has a slow response in comparison to certain servo systems. His attention wanders, and he makes mistakes. He needs rest, relaxation, and refreshment. On the positive side, we can mention his wide versatility as a sensing system, his computing and judgment ability, and his adaptive optimalizing servo characteristics. Finally, we would mention the regenerative or self-repairing characteristics of man by which, after rest and food, the body and mind are fitted again for another period.

### Space Mission Factors

There are several factors which contribute to a change in our thinking regarding flight control between current weapon systems and space vehicles. One of the outstanding differences between conventional weapon systems and space vehicles is the tremendous increase in operational, or mission time, associated with many space vehicles. As an example, a mission time for a conventional aerodynamic missile may be eight hours, whereas a satellite may be required to operate continuously for one year or even longer.

Along with this increase in required mission time is an attendant increase in the reliability problem of the flight control subsystem and other subsystems, too, of course. Fig. 2 shows the effect of mission time on the probability of success of a space vehicle automatic attitude control system. It is assumed that the system is required to operate continuously while controlling attitude about three axes. For comparative purposes, the probability of success and mission time are indicated for a typical missile and a moon rocket. Note that if this space control system were only required to operate over the mission time of a typical aerodynamic missile, the estimated probability of success is reasonable (about 0.97). However, if this same system must control a moon rocket during its travel from earth-to-moon and return, the probability of success is prohibitively low (about 0.22). If additional subsystem reliability, including guidance, APU, etc., are considered, success becomes even less likely.

Table 1 gives an indication of the increase in control system reliability that might be realized by using man to take an active part of the control of the vehicle and to serve as a repairman. The first reliability value shown is similar to that on the preceding figure for an automatic attitude control system. The second reliability value shown is computed for the same system with the crewman providing attitude sensing and corrective inputs to the remainder of the system. Although the reliability is still not as high as desired, the chances of mission success are greatly increased over the automatic system. The third reliability value is computed for a system similar to the second example. However, in the third case, three spare units are considered available—a spare rate gyro, a spare signal shaping network, and a spare inertia wheel system. It is also assumed that the crewman could detect failures and use any of these spares to replace failed components in the pitch,

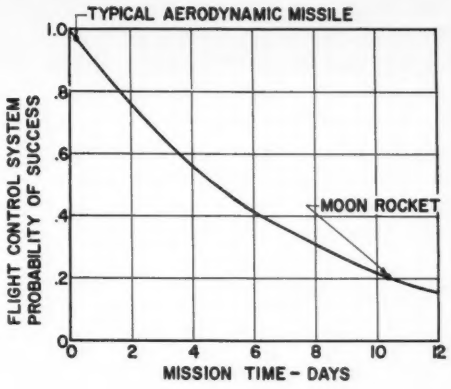


Fig. 2.

yaw, or roll axis control channels. The resulting reliability is certainly more assuring than the estimated value for the automatic system.

These examples indicate two main points:

(a) First, space vehicle reliability is certainly a problem.

(b) Second, by inclusion of the man in the space vehicle, a major improvement can be effected.

Another factor to be considered is the changed characteristics of space vehicles due to the advanced configurations and new regimes of flight as compared to our more conventional vehicles. For example, the rate of attitude change of a lunar type vehicle due to expected space disturbances is so small, much lower than in a normal aircraft, as to be easily controllable by either human or automatic actuation. Another flight phase where changed dynamics would be in evidence would be re-entry. A short period frequency of 3 cpm is a typical value for high lift drag ratio vehicles corresponding to flight at a Mach Number of 18 and an altitude of 200,000 ft. Damping of the oscillations under these conditions would be extremely low, and between 15 and 20 min. would be required to damp the half amplitude after a disturbance. This same vehicle would have a short period frequency of approximately 15 cpm at the approach speed at sea level. These characteristics are such that a pilot could adequately control the vehicle, although a damping augmentation system might be desirable or necessary. Another point of significance in re-entry is the wide change in flight characteristics during the descent. Automatizing equipment to handle such a descent is no easy task. The adaptive servo technique now under development may help greatly. In this connection, it is interesting to note that man is the first adaptive servo mechanism, and this is precisely the kind of flight control situation in which he shows one of his best capabilities.

Space operations, of course, dictate new control systems. One interesting and significant fact with regard

Table 1.

| | |
|---|---|
| Automatic attitude control (two redundant astro-trackers) | 0.22 |
| Human attitude sensing | 0.70 |
| Human attitude sensing and repair (one spare rate gyro, shaping network, and wheel system) | 0.93 |

to reaction controls on a space vehicle is that these control systems command an angular acceleration of the vehicle rather than an angular velocity as with conventional aerodynamic surfaces. This introduces new response characteristics to the pilot. Some vehicles will need both the space controls and aerodynamic controls. This will bring on flight control design problems of mixing and integrating the control systems. However, no problems beyond man's capabilities are foreseen.

**Review of Space Mission**

We have looked at the basic capabilities of man and then at several factors that cause a change from our aircraft-missile thinking. Let us now look at the phases of a space mission to decide on the basis of this background material what the possible roles of the human being might be from the flight control standpoint. The various phases involved in a lunar soft landing mission include boost, space flight, landing on the moon, take-off from the moon, re-entry into an atmosphere, and approach and landing. These phases also exist in more advanced missions such as interplanetary flights. Although the space flight phase is considerably longer and re-entry at other planets will involve different gravitational and atmospheric characteristics, no new phases are inherent in these missions.

During the boost phase, the use of the pilot for initiation of escape in case of impending booster explosion might be considered. However, as a result of the rapidity at which such sequence of events proceeds and man's relatively slow reaction time, actuation of emergency escape rockets will probably be performed automatically as a result of signals picked up from the main booster. The pilot might also be used in this phase for controlling the cutoff of the engines, steering the vehicle onto the correct path, or signaling attitude stabilization. The timing of main propulsion cutoff is so exacting as to make human control of this feature to the desired accuracy difficult. If, however, a measure of vernier propulsion is made available, control and adjustment of the final velocity vector by the pilot may be possible. The use of the pilot for a backup emergency control may be practical for certain vehicles and missions with a possible degradation in mission performance. Some reduction in control system complexity and increase in probability of success could thereby be gained. The above uses of man, although desirable considerations in case he were included for other reasons, do not offer any overriding arguments for incorporation of man in the system as compared to an automatic system.

In the space flight phase of the mission, there are a number of possibilities that could be considered. In view of the low rates of angular motion resulting from the small disturbances expected, the pilot would have no difficulty in performing attitude stabilization assisted by suitable displays and possibly an automatic damping system. The mission to be performed would determine the necessity for keeping close tolerances on attitude over long or short periods. It is possible that the pilot might be used to make occasional corrections to a rudimentary automatic stabilizing system and thereby save weight and complexity. Satisfactory automatic attitude stabilization systems are within the state of the art, but for long mission times the reliability problem as discussed earlier is exceedingly severe.

In connection with attitude control, the pilot might be used as the energy source. It is within the pilot's capabilities in certain cases to provide the necessary moments by directly driving inertia wheels. Since it may be desirable from the physical well-being standpoint for the pilot to have some exercise, these two considerations may be satisfied at one time. It is not safe to extrapolate that since man needed supplementation or replacement as an actuator in conventional aircraft that this is the case in all space missions. A more detailed study of a given vehicle and mission will be needed to determine the possibilities.

Once propulsion has reached the point where even a slight excess of energy is available over and above what is needed for a minimum energy trajectory, we will start to talk about path control. Numerous missions, military or otherwise, can be conceived which would require path control. The human pilot could contribute to prediction of the necessary corrections and application of the proper forces to achieve the new path. The time intervals to determine actions required would be long and well within the pilot's capabilities. The function would be more analogous to navigation calculations and drift corrections than to operation in the conventional piloting sense. It would possibly involve the pilot's making certain observations, making computations supplemented either by on-board or ground-based computers, and then orienting the vehicle and firing a specific rocket impulse.

Certain missions might require tracking. This could be for purposes of reconnaissance, launching missiles or bombs against targets, or investigating other spacecraft. The servo characteristics of man might be used to excellent advantage for these uses.

As a result of the extreme reliability problem previously pointed out, the use of the human pilot as a repairman of the flight control system offers one, if not the most important, use of man. Of course, he could serve in this capacity in increasing the reliability of other subsystems. References 4 and 5 discuss further this problem area.

The judgment abilities of man with regard to the flight control and other aspects will be extremely hard to duplicate with automatic equipment. For military missions where observations must be made and action taken immediately in the light of a number of possible decisions, the only probable alternative to the on-board intelligence is the relay of necessary data to a man on the ground. This may or may not be practicable.

In considering making a soft landing on an airless body such as the moon where gravity is present or on a space station where gravitational attraction is nil, we are faced with a tracking problem similar in many respects to control of a VTOL vehicle such as the X-13.

(*Continued on page 67*)

# Should the Laws of Gravitation Be Reconsidered?

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## Complementary Note

*New information concerning the results indicated in Parts I and II of "Should the Laws of Gravitation Be Reconsidered?" published in the September and October issues.*

THE EXPERIMENTS which I have made simultaneously (during June and July, 1958) on two identical installations in my laboratory at Saint-Germain and in a new laboratory at Bougival, in an underground gallery 57 meters deep, have shown that the previously observed anomalies are still present and that they possess, in both cases, periodic structures which are interrelated in a remarkable manner.[1]

For illustration purposes, I give in Fig. 1 a graph representing the results of harmonic analysis obtained by the Buys-Ballot filter method over a period of 24 hours, 50 min., starting from day and night observations made simultaneously in both laboratories during a month (from July 2, 0 hour Universal Time to July 31, 23 hours, 40 min., Universal Time) under the conditions *identical* to those of my experiments during the period of June-July, 1955.

This graph permits a comparison of results obtained in both the Saint-Germain and Bougival laboratories. The difference in the amplitude of both waves is very small, and they possess a remarkable concordance of phase.

These parallel experiments made at the same time and under the same conditions allow the introduction into my earlier argument of elements of great value for the elimination, with a high probability if not absolute certainty, of almost the totality of proposed explanations for the observed periodic effects. I will simply indicate that

(1) Alone, the practical identity of the periodic effects of 24 hours, 50 min., observed at Saint-Germain and Bougival permits the elimination of any explanation by a casual cause.

(2) In the same way, the practically invariable temperature conditions realized in the Bougival laboratory permit the elimination of any thermal effect.

(3) The parallelism of the periodic effects observed at Bougival and Saint-Germain leads to the elimination of any effect based on the influence induced by the building or on that of any superficial cause.[2]

(4) The relatively large variability with time observed in the amplitude of the periodic effects permits the elimination of any explanation based on the actually admitted laws of gravitation.

*Thus, the results of my experiments (July, 1958) confirm, in a striking manner, my earlier argument leading to the conclusion that there exist in the motion of a paraconical pendulum on an anisotropic support anomalies of the periodic character which, at this point of the discussion, cannot be tied with any known phenomenon.*

### Notes

[1] The reader could usefully refer himself to the four following notes which I presented at the Academy of Sciences at the end of 1958:

*New Experiments on the Paraconical Pendulum on an Anisotropic Support*, C.R.A.S., 247, 1958, p. 1428.

*Periodical Structure of the Motion of the Paraconical Pendulum at Saint-Germain and Bougival, July, 1958*, C.R.A.S., 247, 1958, p. 2284.

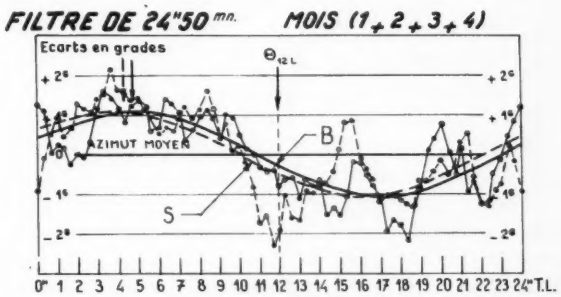
*Experimental Determination of the Effect Produced by the Anisotropy of the Support on the Motion of the Paraconical Pendulum*, C.R.A.S., 248, 1959, p. 764.

*Experimental Determination of the Effect of Inclination of the Support on the Motion of the Paraconical Pendulum*, C.R.A.S., 248, 1959, p. 359.

[2] In particular, the explanation presented by Mr. Goguel (*Remarks on the So-Called Paraconical Pendulum*, C.R.A.S., Vol. 246, No. 16, April 21, 1958, p. 2340) attempting to explain the observed phenomena by the combined effect of the wind and building cannot be accepted.

### ADDENDUM I—

### Simultaneous Experiments Made During the Month of July, 1958, at Bougival and Saint-Germain


FILTRE DE 24"50 mn.
MOIS (1 + 2 + 3 + 4)
Ecarts en grades
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S
- 1g
- 2g
0h 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24h T.L.

Fig. 1. Buys-Ballot's filter of 24 hours, 50 min. (deviation in centesimal degrees). Month (1 + 2 + 3 + 4)—test sequences. Key: _____ represents tests at Bougival, - - - - - - represents tests at Saint-Germain; thin line represents mean cycles, heavy line represents adjustment sinusoids.

| | $2R$ (in centesimal deg.) | $\Theta - \Theta_{12\,L}$ (local time) |
|---|---|---|
| Bougival | 2.17 | −7 hours, 23 min. |
| Saint-Germain | 2.10 | −7 hours, 55 min. |

*Complete scavenging of the jet exhaust products of combustion is one of the basic requirements of the closed-circuit arrangement, together with a supply of "make-up" air to compensate for that removed by the exhaust system.*

*Aerodynamic and thermodynamic problems of the scavenge system - tunnel combination are considered, and some results are included from special experimental studies undertaken in connection with the engineering design.*

## Design and Development of the

# Jet Exhaust Gas Scavenging System

## for the AEDC Propulsion Wind-Tunnel Facility

Carl J. Wenzinger, AFIAS

Sverdrup & Parcel Engineering Co.

Some of the basic design requirements originally established for the Propulsion Wind Tunnels of the Arnold Engineering Development Center (AEDC) were that they should provide facilities for:

(a) Wind-tunnel testing of complete full-scale operating propulsion systems as installed in aircraft or missiles over as full a range as possible of the altitude-Mach Number simulation.

(b) Aerodynamic testing of complete models with "burning jets" and components of aircraft and missiles.

(c) Development testing of ram-jets with complete internal and external flow.

(d) Future tests of rockets.

Analytical studies were made (1949–1950) to determine the most useful and practical size and shape of test section for the facility within certain fixed funding. The studies included power-plant installations of aircraft and missiles in the development stage at the time, and estimated future arrangements for the next 5- and 10-year periods. Based on the results of these studies and estimated numbers of test runs for various configurations, a maximum test section size of approximately 16 ft. square in cross section and 40 ft. long was established. The facility was specified to be of the continuous-flow closed-circuit type to cover the Mach range from about 0.5 to 3.5 (later extended to 5). Supply power available at the time limited the compressor drive horsepower initially to 216,000 and provided for a proposed altitude range of sea level to 100,000 ft.; structural considerations limited the maximum total temperature level to about 650°F. Temperature-pressure matching would then be available up to Mach Number of about 3, beyond which the tunnel would operate too cold for simulated altitude conditions.

Other studies and investigations resulted in the present configurations and general arrangement of Propulsion Wind Tunnel (PWT). This facility actually consists of two separate wind tunnels (see Figs. 1 and 2), each with its own compressor but coupled to a common drive system. The complete drive system, using four electric motors, can be coupled to one tunnel or the other, or half of the drive can be coupled to each tunnel simultaneously. The Transonic Circuit was designed to cover a Mach range from about 0.5 to 1.6, while the Supersonic Circuit was designed to start at $M = 1.5$ and extend to approximately $M = 5.0$. Estimated altitude-Mach Number performance of the PWT obtained from some recently published data is indicated in Fig. 3.

One of the unique features of this facility is the closed-circuit configuration with complete scavenging of the jet exhaust products of combustion, a feature not existing in any other closed transonic or supersonic tunnel. This combination makes it possible to simulate a wide range of altitude conditions and Reynolds Numbers, compared with the existing open-circuit configurations exhausting directly to atmosphere. The closed circuit requires, of course, a supply of "make-up" air to compensate for that removed by the exhaust system. An additional feature arose in the case of the PWT, particularly for the Transonic Circuit, in that a "plenum evacuation system" external to the tunnel had to be incorporated for removing the boundary-layer air by

**At the time of the work discussed in this paper, the author was Principal Engineer and Head, Aeronautical Section. He now is Executive Engineer, Advance Planning, Cook Research Laboratories Division, Cook Electric Co.**

Mr. Wenzinger was responsible for the general arrangements and detailed aero- and thermodynamic designs of the facility discussed here. One of the Institute's Founder Members and holder of Electrical and Mechanical Engineering degrees from Swarthmore College, he became associated with Sverdrup & Parcel in 1949 after 16 years with NACA at Langley Field. While with NACA, now NASA, his best known contributions were associated with development of many of the high-lift and lateral-control devices in use on today's aircraft. His World War II service included duty as Officer-in-Charge of the Aeronautical Laboratory, Navy Taylor Model Basin (with additional duties in BuAer), and as a member of a special Naval Mission to Europe to investigate aerodynamic and propulsion activities of the Germans and French.

suction from the perforated walls that were especially developed for the test section, and that air then compressed and reinjected into the tunnel circuit downstream. This permits testing of high blockage configurations without "choking" the test section, and, in addition, reductions can be controlled of the wave reflections at the test section walls.

## Engineering Design Problems

The problems encountered in the scavenge system may be considered in two broad categories—those having to do with the flow of the exhaust jet and the tunnel mainstream and those having to do with what may be termed the mechanics of the system.

Specific problems of an aerodynamic nature may be listed as:

(a) Scoop inlet design.

(b) Scoop inlet position (with respect to exhaust jet outlet).

(c) Diffusion of scavenged gases within the scoop.

(d) Conveyance of scavenged gases from PWT to exhaust compressor system.

(e) Design of scoop-tunnel diffuser combination.

(f) Make-up air injection.

Some problems of a mechanical nature are:

(a) Cooling of scavenged gases.

(b) Mounting of the scoop within the tunnel.

## Experimental Studies

### *Jet Exhaust Spreading*

The exhaust scoop was one of the main items to be designed and developed, and the primary performance requirements established for it were:

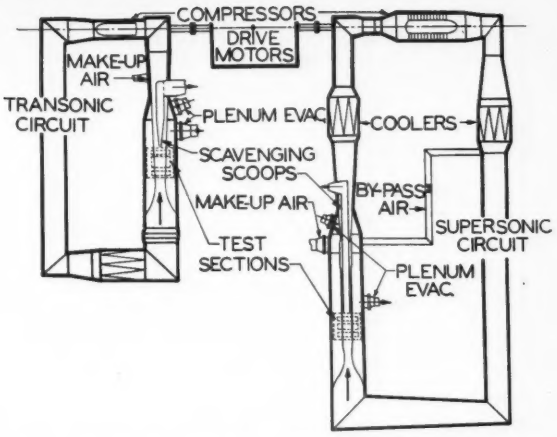


Fig. 1. The Transonic and Supersonic Circuits of the AEDC Propulsion Wind Tunnel.

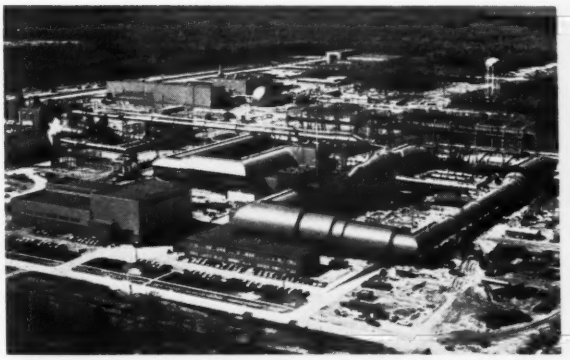

Fig. 2. Aerial view of the AEDC Propulsion Wind Tunnel.

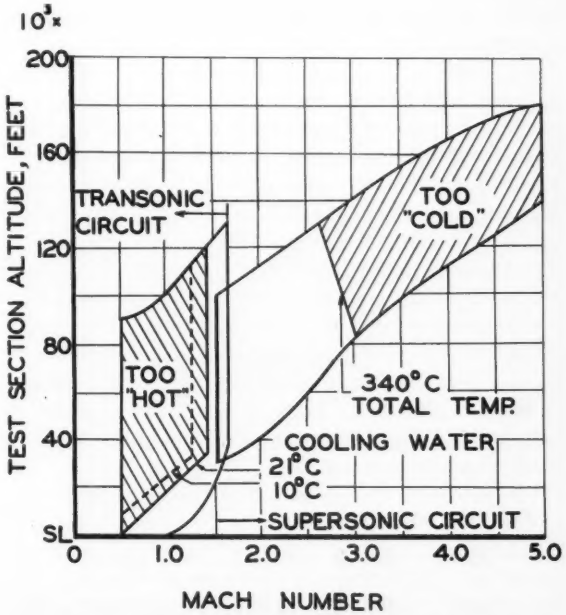


Fig. 3. Altitude-Mach Number performance of the PWT.

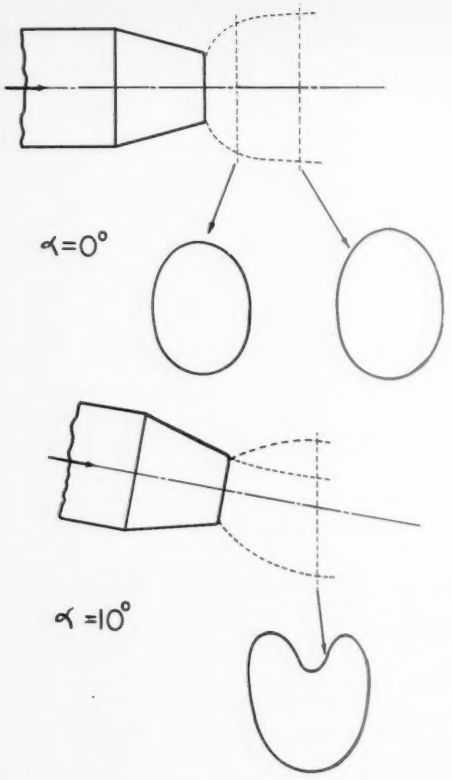


Fig. 4. Exhaust jet profiles and boundaries.

(a) Complete scavenging of the exhaust gases.

(b) Size compatible with anticipated turbojets, ramjets, and rockets.

(c) Adjustment in pitch to accommodate engine angles of pitch to 10°.

(d) Minimum effect on tunnel diffuser.

Test programs were carried out at the United Aircraft Research Department during 1951–1952 and included both hot and cold model turbo- and ram-jets at subsonic and low supersonic tunnel Mach Numbers. Several scoop-to-jet diameter ratios, several scoop locations, and several scoop inlet configurations were tested. Additional tests were made at the Jet Propulsion Laboratory of the California Institute of Technology (1953) to determine the spreading characteristics primarily of hot supersonic jets exhausting into a supersonic stream.

Some typical results from the tests are shown in Fig. 4 for the jet at 0° and 10° angle of attack. The expansion of the jet at different axial stations downstream of the nozzle exit is illustrated quite clearly. The contours obtained at 0° and 10° angle of attack differ considerably, in large measure because of vortices shed by the model at angle of attack.

Test results at 1.5 jet diameters downstream for the simulated turbojet are plotted in Fig. 5 as the ratio of the diameter of the spread jet to the diameter of the nozzle exit versus the Mach Number of the expanded jet. The experimental curve is seen to lie considerably above the theoretical curve indicating the rather high degree of mixing between the exhaust jet and the tunnel airstream.

Analysis of surveys of the jet and of schlieren photographs taken as part of the tests led to the following important conclusions:

(a) Scoop-jet diameter ratios as large as 1.75 may be required in the Transonic Tunnel for hot jets. Cold jets are less critical in importance.

(b) Scoop positions as close as 1.5 jet exit diameters downstream of the jet exit may be used without apparent interference effects on the model at the low Mach Numbers.

(c) Simple conical or parallel-conical scoop inlets appear satisfactory.

(d) Adequate cooling of the lips of the scoop inlet is of great importance.

(e) The simple conical-inlet scoop indicated reasonably high total head recoveries.

### *Scavenge Scoop - Diffuser Combination*

Since the high power requirements of the PWT were a very important item of equipment and operating costs, all losses in the tunnel circuits had to be kept to a practical minimum. Considerable information was available regarding the performance of variable-geometry diffusers, but none of the data or existing theories was adequate to predict the effects of the scavenge scoop on diffuser performance. Experimental investigations were therefore conducted at various laboratories (University of Minnesota, Naval Ordnance Laboratory, United Aircraft Corp., University of Texas) to determine the optimum performance and configuration for the design of the scavenge scoop - variable geometry diffuser combination primarily for the PWT Supersonic Circuit.

Effects upon diffuser performance were determined for items such as Mach Number range, Reynolds Number, scavenge-scoop configuration, second-throat configuration, etc., and with and without a model in the tunnel test section. As a result of these investigations, suitable arrangements were developed for both the PWT Transonic and Supersonic Circuits. The com-

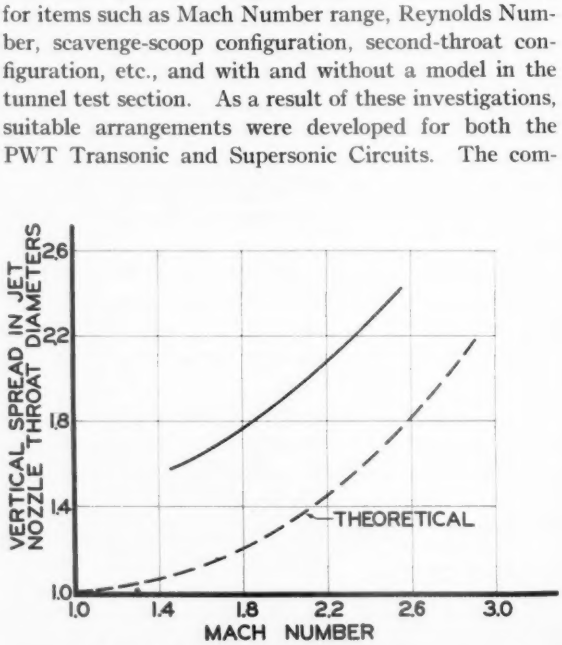


Fig. 5. Jet spread with expanded-jet Mach Number.

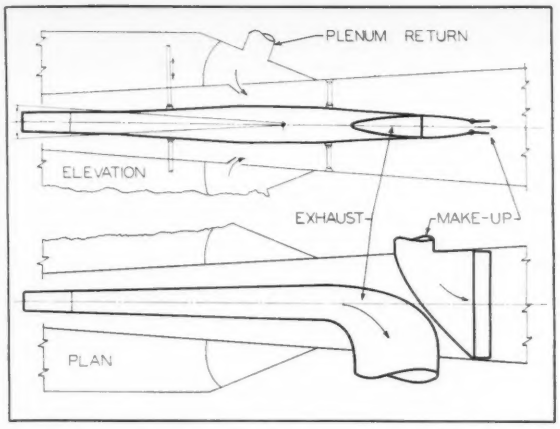


Fig. 6. PWT Transonic Circuit scavenge scoop - tunnel diffuser.

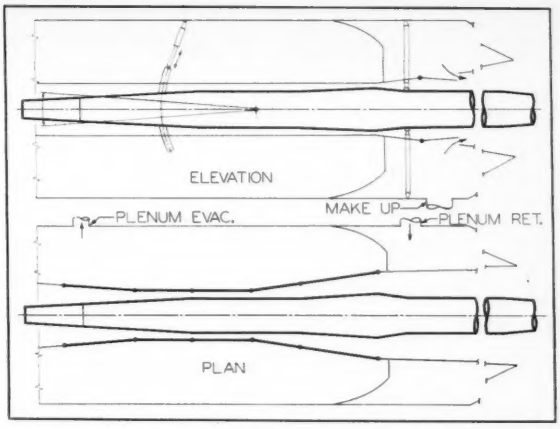


Fig. 7. PWT Supersonic Circuit scavenge scoop - tunnel variable geometry diffuser.

binations decided upon as most satisfactory for the requirements are outlined in Fig. 6 with fixed diffuser for the Transonic Circuit, and in Fig. 7 with variable-geometry diffuser for the Supersonic Circuit.

### *Make-Up Air*

All products of combustion are to be removed by the scavenge system in order to avoid contamination, and all air-fuel mixture exhausted by the propulsion unit before starting must also be removed to minimize any danger of explosion in the circuit. A certain amount of tunnel air is thus removed by scavenging, and the entire mass must be replaced with fresh air. This mass of air must be conditioned and introduced into the tunnel so as not to cause excessive losses in the basic tunnel circuit.

In addition, although not directly concerned with the scavenge system, the boundary-layer air previously mentioned as being removed from the test section walls must also be reintroduced into the tunnel without causing excessive losses. The two systems are thus somewhat interrelated in this respect, and that part of the problem was analyzed and the solution arrived at for the combination of effects. Figs. 6 and 7 also indicate the basic arrangements used for reinjection in both the Transonic and the Supersonic Circuits.

When products of combustion are not being removed from the airstream as in the case of purely aerodynamic tests, then the scoop, exhaust, and make-up air systems are used only to set and adjust the pressure and humidity levels in the wind-tunnel circuit. In this case, it was found that it may be desirable to use a different shape of scoop inlet to provide for somewhat more efficient diffuser recovery.

## Cooling and Structural Considerations

### *General*

The exhaust jets issuing from the operating propulsion units were considered to be at a high temperature, approximately 3,500°F., and also to contain some combustible gases which could ignite under certain conditions. This means, of course, that the scavenged gases must be cooled and the entire scavenging system itself protected from high temperatures. Items to be considered were scoop inlet, scoop diffuser, connecting ducting to exhausters, and exhauster units.

A chart was prepared which provided the basis for a large portion of the thermodynamic calculations for spray cooling and dehumidification. This chart is illustrated as Fig. 8 and is interpreted as follows: The initial exhaust gas condition is indicated by the intersection of the 3,500°F. curve with the "water of combustion" curve. As spray cooling is applied, the temperature of the exhaust gases will decrease while their specific humidity will increase as shown by the curve. This process will continue until the saturation temperature corresponding to the pressure in the cooling chamber is reached. Further cooling will then proceed along one of the curves labeled "saturation curves" and will continue as long as the cooling water is able to absorb heat.

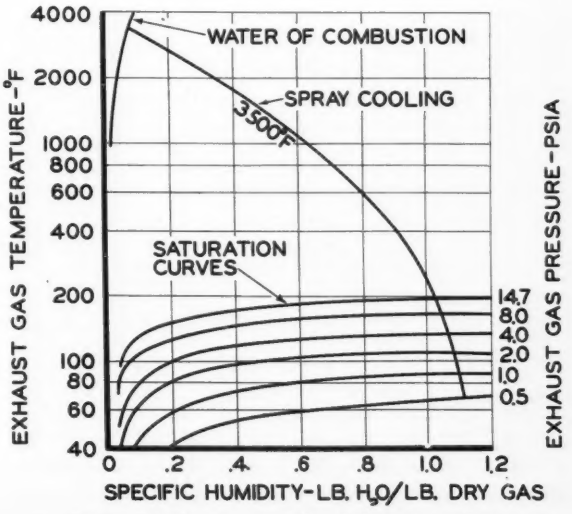


Fig. 8. Jet exhaust gas conditions during spray cooling.

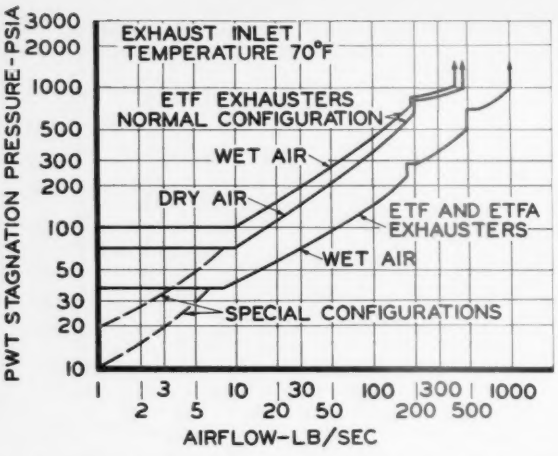


Fig. 9. Scavenging capacity as a function of tunnel stagnation pressure.

### Cooling

Some analytical studies were made initially of cooling methods. Assuming that the scoop diffuser material could withstand the high temperature, it was found that only a relatively small drop in the gas temperature would occur (5° to 6°F. per foot of duct) from combined convection and radiation. In addition, because of the high initial temperatures and restricted space and mechanical considerations, "dry cooling" by some type of shell and tube heat exchanger within the scoop diffuser was not feasible.

Other methods considered were external duct surface cooling by water, internal surface water-film cooling, water-jacketing, and direct water spray cooling of the hot gases. It was determined that spray cooling was the most advantageous method and that scavenged gases should be spray cooled to near saturation as soon as possible. In order not to induce choking within the duct, spraying should not begin until the gases have been diffused to a moderate Mach Number ($M = 0.6$ to 0.75).

As noted previously, test results indicated the great importance of adequately cooling the lips of the scoop inlet. However, because of its limited entrance size and the high velocity of the entering gases, water-jacketing and spray cooling were not feasible. The inlet portion of the scoop was therefore designed as a replaceable section of stainless steel, approximately three inlet diameters long, without water cooling. This arrangement also permitted the use of different sizes and shapes of that part of the installation. The walls of the scoop diffuser between the replaceable tip section and the saturation sprays were protected by water-jacketing for the Transonic Circuit, and by film cooling for the Supersonic Circuit.

### Water Requirements

A special study of spray cooling, undertaken at the University of Minnesota, gave information from which the quantities of cooling water and spray bank arrangements could be determined. It was assumed that the hot gases would be spray cooled down to a point near saturation, about 200°F., which would give a specific humidity of roughly one pound of water per pound of dry air. The actual distance required for the spray to cool to 200°F. was determined to be quite small so that a relatively short length of duct was needed following the saturation sprays to permit the water to evaporate and the flow to stabilize before making the turn into the duct leading out of the tunnel. It was not necessary to cool the scavenge duct downstream of the saturation sprays because the gas temperature would be low enough for the structural steel to withstand.

Based on some proposed propulsion units expected to be tested, the amount of water required for spray cooling to 200°F. was calculated at about 2,000 gal. per min. The condition of engine "flame-out" or "cold-flow," as well as the need for fire protection, dictated the use of the maximum amount of 4,000 gal. per min. cooling water flow.

The excess free water must be removed from the scavenge system to protect valves and turning vanes in the ducting from damage and also to minimize any hazard of "water hammer." In addition, some provision for water separation must be made to safeguard the blading of the exhauster machines. Water drains were located at several elevations above grade in the scavenge system and empty into a barometric well

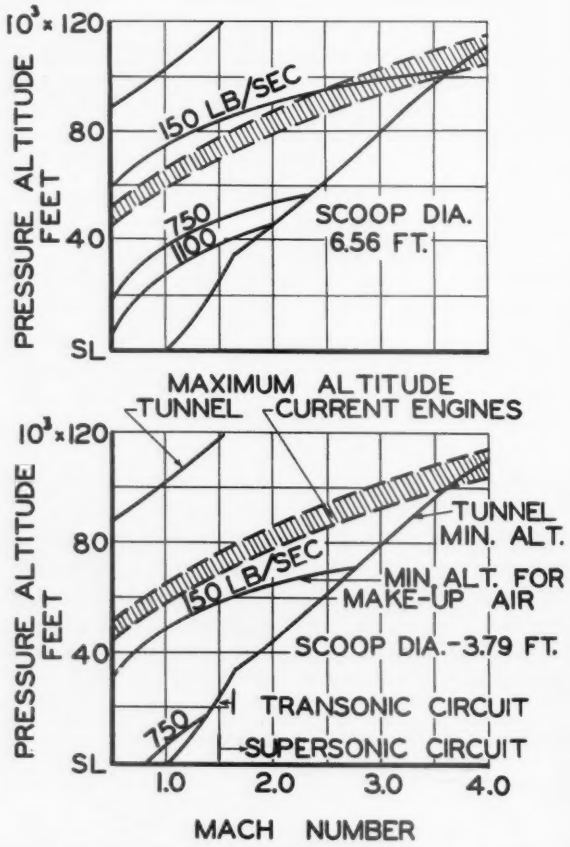


Fig. 10. Make-up air capacity effect on PWT performance for two scavenge scoop sizes.

which maintains a water leg seal of the ducting. A separator of the "Centifix" type is located near the inlet to the exhausters to further assure adequate removal of any excess water.

### Exhauster and Make-Up Air

#### *Exhaust System*

The scavenging system, as pointed out previously, will capture the supersonic jet gases and some tunnel air, and diffuse the mixture to subsonic speeds. These gases will then be cooled and exhausted to atmosphere by means of the exhaust compressors associated with the existing AEDC Engine Test Facility and Engine Test Facility Addition (ETF and ETFA). Estimated capacities of the ETF and ETFA exhauster system from some recently published data[1] are shown in Fig. 9 as a function of the PWT stagnation pressure. The ETF exhaust system is now available for exhausting and tunnel pressure level control, and the additional increment in the ETF exhaust system will soon be available.

The minimum allowable scoop inlet size would be selected for a given engine nozzle exit and, depending upon the jet spreading expected, would be located for interference-free conditions. The scoop inlet size then fixes the scavenging and make-up air requirements, which thus determine the available operating range for the given engine in the PWT.

#### *Make-Up Air System*

In order to maintain desired tunnel mass flow conditions, make-up air equal to that scavenged must be re-injected into the tunnel circuit at a sufficient dryness to prevent condensation of moisture particles in the air. The air supply system of the ETF-ETFA test facilities already available was therefore selected as the main source of continuous-flow make-up air for both the Transonic and Supersonic Circuits of the PWT. This air supply system includes both heating and cooling equipment so that tunnel requirements can be met within certain limits.

The make-up air temperature must be maintained at the temperature of the tunnel main stream so as not to affect the compressor performance. Although the temperature in the stagnation chamber of the Supersonic Circuit will reach a maximum of 650°F., the airflow will be cooled prior to re-entering the compressor by (a) the pressure drop across the nozzle, (b) the make-up air which will not exceed 175°F., and (c) a cooler (by-pass) just downstream of the test section.

Since the only parameters requiring close matching to the tunnel main stream are the temperature and weight flow of the circuit, the injection pressure of the make-up air can be held equal to or greater than the total pressure at the injection location. Control of the pressure will be used to energize the wake from the trailing edge of the scavenge scoop support strut for the Transonic Circuit as indicated in Fig. 6, and to improve the diffuser recovery in the Supersonic Circuit (Fig. 7).

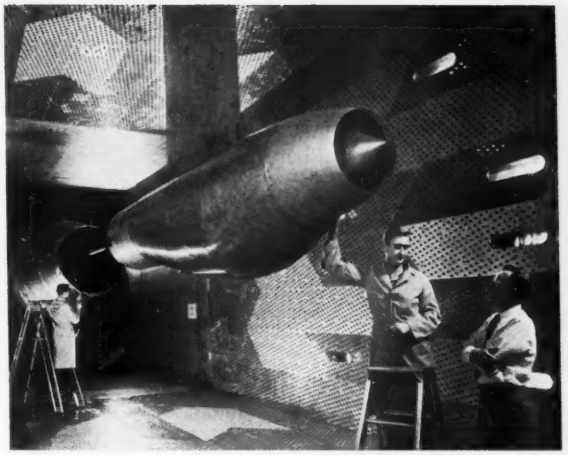

Fig. 11. Full-scale propulsion unit set up for test in the transonic test section.

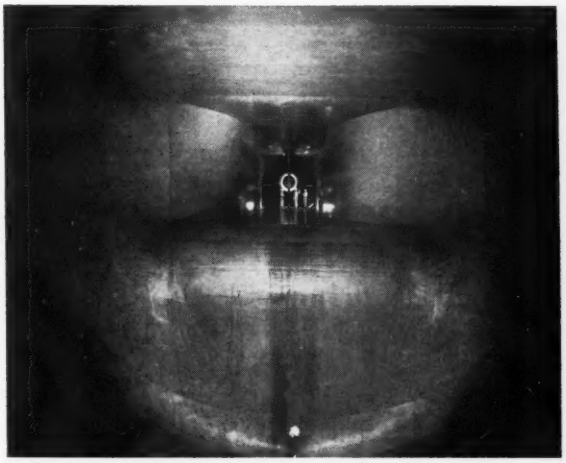

Fig. 12. View of transonic test section from stagnation chamber.

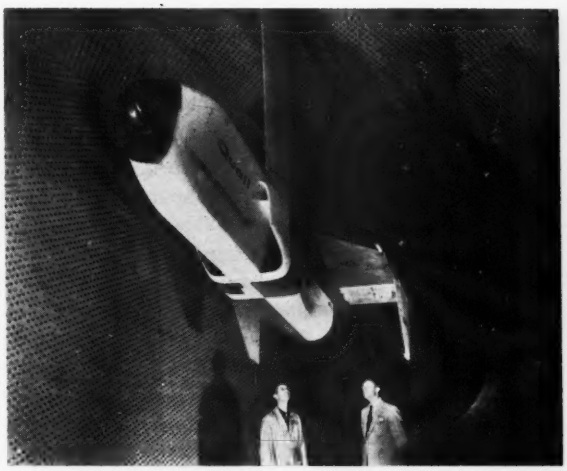

Fig. 13. The Quail (GAM-72) missile installed for test in the transonic test section.

Should the continuous flow make-up air supply system not be capable of replacing all the scavenged air for the PWT, then a penalty of decreased tunnel performance is imposed if constant tunnel flow conditions are to be maintained. In the case of the PWT, where altitude simulation is a basic requirement, this penalty would show up as a limitation on the minimum altitude simulation attainable for any given weight flow of make-up air. Fig. 10 shows the effect of make-up air capacity on PWT performance for two different scoop inlet sizes.[2]

### Full-Scale Tests

#### *Experimental*

Some tests were recently completed in the PWT Transonic Circuit of a full-scale propulsion unit to evaluate effects of scavenging-scoop proximity, scavenging flow rate, and scoop angle of attack on interference experienced by the test article, on tunnel airstream contamination, and on engine and tunnel operations. The engine-pod installation with supersonic air-inlet configuration and nacelle housing a Westinghouse J-34 turbojet engine is shown set up in the test section in Fig. 11. A view of the empty test section looking downstream from the stagnation chamber is shown in Fig. 12.

These test results indicated[3] that interference-free testing is possible over the complete range of tunnel Mach Number (0.8 to 1.6), altitude (20,000 to 60,000 ft.), and test article angle of attack ($-7°$ to $10°$) used in the tests. Scavenging flow rates required to produce interference-free testing were found to fall well within practical modes of tunnel and scavenging system operation. In addition, contamination-free testing was found to be possible for all modes of operation producing interference-free operation.

#### *Complete Missile*

An investigation of the full-scale Quail missile (GAM-72), manufactured by McDonnell Aircraft for the U.S. Air Force, was recently conducted in the PWT Transonic Circuit (see Fig. 13). The tests duplicated the Quail flight regime of Mach Numbers and pressure altitudes with the primary object being investigation of the turbojet engine-airframe compatibility. Special emphasis was placed on determination of the engine stall and performance characteristics as integrated with the air-induction system.

A total of 42 hours' engine operation and data recording was obtained during a tunnel usable occupancy time of 80 hours which would have required well over 100 flights and a much longer time to obtain similar data. The operation of the tunnel, scavenge system, and associated equipment bore out to a satisfactory degree the design and development predictions of the facility performance.

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[2] Hensel, R. W., and Matt, H. K., *Full-Scale Propulsion Testing in Wind Tunnels*. Preprint of AEDC paper presented at Joint Meeting of AGARD Combustion and Propulsion Panel and Wind Tunnel Panel Held in Copenhagen, Denmark, Oct. 20–29, 1958.

[3] Delano, James B., *Full-Scale Propulsion Testing in the 16-foot Transonic Circuit, AEDC*, AEDC-TN-58-31 (ASTIA AD-157141), June, 1958.


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## Measurement of Angular Acceleration (Continued from page 50)

Note: for $\dot{\theta} = 0.02°/\text{sec.}$

$\theta = 1$ sec. arc

$H/I_0 = 900$

then $\omega_n = 280$ rad./sec. (45 cps) as desired.

### Double Differentiation of Displacement Angle

The advantages which were discussed for the rate gyroscope are applicable to the vertical gyroscope in theory. The same process of measurement, numerical filtering, and differentiation could be followed except that the differentiation process must be repeated. The basic disadvantage is the relative aircraft response in angular displacement compared to angular rate. In most cases of interest, rather appreciable rates are associated with very small angles. Only in the very low frequency mode (fugoid mode) is the pitch angle changed to the point where a vertical gyroscope can be used to advantage.

Fig. 2 shows the response frequency of the aircraft plotted against angular displacement, rate, and acceleration. In the range of general interest, angular displacement is too far in the mud for proper use. This comparison shows an additional reason for the use of rate gyroscopes.

### Conclusion

It appears that, as an instrument for measuring pitching motion, the rate gyroscope is far superior to the angular accelerometer. For very accurate measurements of angular acceleration, a rate gyro output, filtered and differentiated numerically, will provide excellent results. This implies a marriage of the rate gyroscope and the digital computer.

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Statham Laboratories Instrument Notes Nos. 2, 9, 12, 19, 26.




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*This study "stemmed from a number of failures which occurred in the bottom plating in the planing area of the hull, where high-frequency water pressure loadings are experienced during landing and take-off," but the "method of analytical treatment is applicable to many other aircraft and missile structures where material fatigue must be considered."*

# Statistical Analysis of Seaplane Fatigue

Julius E. Pauken

The Martin Company

QUITE OFTEN the study of aircraft structural fatigue is characterized by a complexity of circumstances that rules out direct analysis and makes it necessary to treat the problem with statistics. Loading, for example, may be random by nature, and the fatigue strengths of materials usually have a scatter of as much as 1 to 10.

Described here is a statistical analysis of structural fatigue in seaplane hull bottoms. Although the problem in this case is of a specific nature, the method of analytical treatment is applicable to many other aircraft and missile structures where material fatigue must be considered. The method of analysis is generally applicable to any flat-web type of structure where pressure loadings are supported by plate bending or by a combination of plate bending and membrane stresses. Examples are any flat or nearly flat webbed bulkheads, partitions, floors, and the like in pressurized aircraft or any flat or nearly flat webbed structures in the pressure vessel regions of missiles or space vehicles.

The study which follows stemmed from a number of failures which occurred in the bottom plating in the planing area of the hull, where high-frequency water pressure loadings are experienced during landing and take-off. The failures were restricted to this one region and usually occurred along the longitudinal stringers which support the plating.

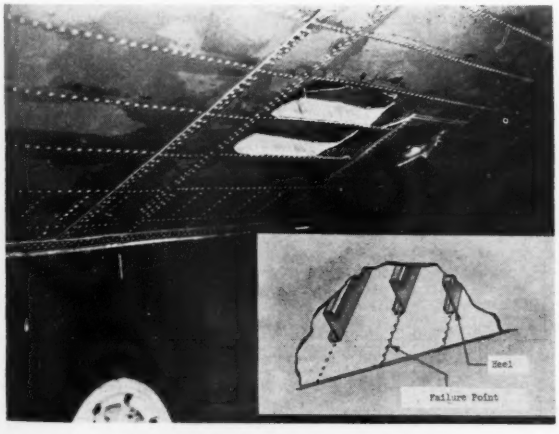


Fig. 1. Typical hull bottom plating failure.

Mr. Pauken has been Assistant Technical Director on the Martin P5M-2 Navy seaplane project, and other special projects, since February, 1959. He joined Martin in January, 1939, as a structural analyst on the famed World War II JRM Mars seaplane transports and later served as an engineer on the structural design and analysis of the 4-0-4 commercial airliner, seaplane hulls and fuselages, and missiles. A native of Maumee, Ohio, he obtained his aeronautical engineering degree from the University of Detroit in 1937.

Plating failures were first noticed in one ship which had completed 530 landings during evaluation flight tests. Similar failures appeared in regular service aircraft with 700 to 1,000 normal landings and take-offs. Fig. 1 illustrates such a failure. The plating is Alclad 7075-T6 of 0.080 gage. The longitudinal stringers are bent-up, return-lipped zees made of 0.064-gage, 7075-T6 stock, spaced 6 in. apart.

In Fig. 2, the failure is seen to follow the rivet line attaching the plating to the longitudinal stringer. The close-up view in Fig. 3 shows that the fatigue line does run along the edge of the rivet line; but it also juts into some rivet holes and just skims by others. This is significant in the light of earlier fatigue tests.[1] Panels simulating typical hull bottom construction were cyclically loaded to high maximum pressures of 45 to 50 psi. The line of failure occurred 1/8 to 1/4 in. away from the rivet line, nearer to the heel of the zee stringer. When panels were cyclically loaded to low maximum pressures of 15 to 20 psi, the line of failure ran through the edge of the rivet holes in a manner similar to that pictured in Fig. 2. Tests to intermediate pressures produced failure lines at intermediate locations. The conclusion is that if the failures were caused by random pressure loadings, these loadings would be of the low rather than of the high maximum variety.

Metallurgical examinations of fractures like those shown in Fig. 3 (upper) have verified the fact that, in

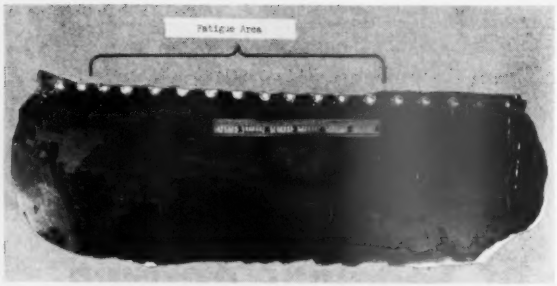


Fig. 2. Typical bottom plating fracture.

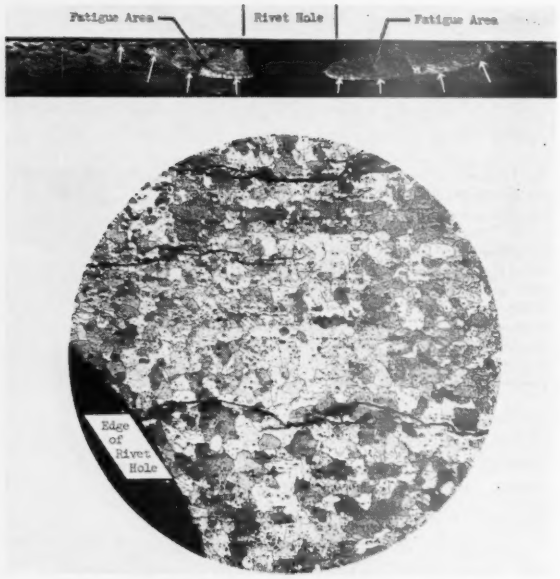


Fig. 3. Magnified views of typical fatigue cracks and failure.

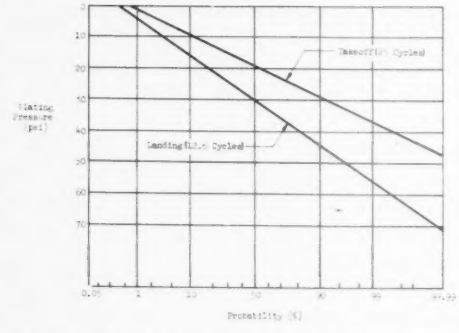


Fig. 4. Probability distribution of typical plating pressures.

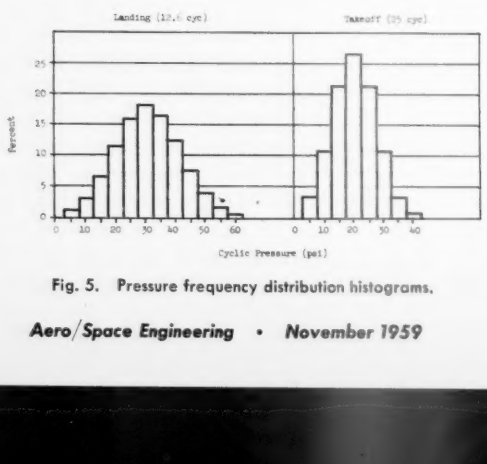


Fig. 5. Pressure frequency distribution histograms.

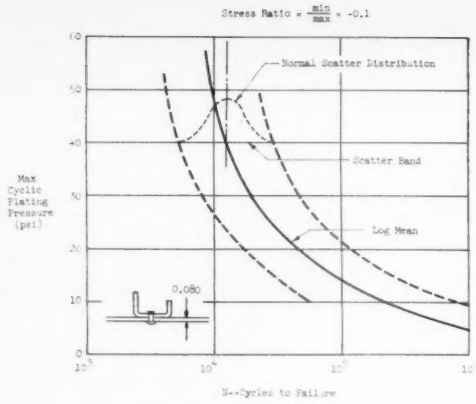


Fig. 6. Fatigue strength of hull plating.

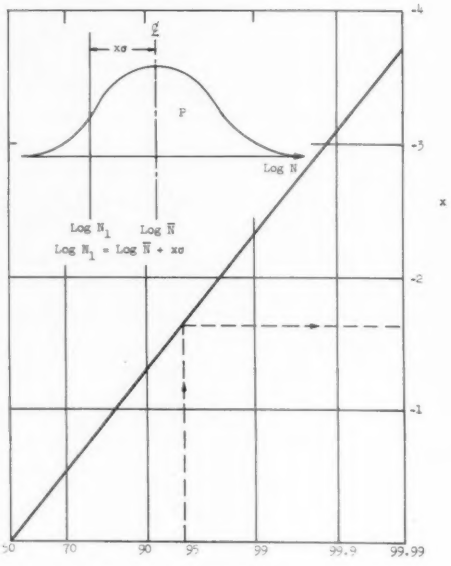


Fig. 7. Fatigue strength scatter.

## Table 1. Fatigue Damage Study

**(Based on Miner's Cumulative Damage Theory)**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Plating Press SF = 0.65 | Frequency Distr--% | | No. of Pressure Cycles for 1,000 Landings and Take-Offs | | | Fatigue Strength Log Mean | |
| | Landing | Takeoff | | | | | |
| 5.85 | 1.012 | 0.036 | 130 | 900 | 1,050 | 8 x $10^6$ | 0 |
| 6.50 | 0.052 | 0.128 | 400 | 2,700 | 3,100 | 7 x $10^5$ | 0.004 |
| 9.75 | 0.067 | 0.213 | 840 | 5,550 | 6,170 | 2.7 x $10^6$ | 0.021 |
| 13.00 | 0.116 | 0.266 | 1,460 | 6,650 | 8,110 | 1.3 x $10^5$ | 0.062 |
| 16.25 | 0.160 | 0.213 | 2,020 | 5,350 | 7,350 | 7.2 x $10^4$ | 0.102 |
| 19.50 | 0.181 | 0.108 | 2,280 | 2,700 | 4,980 | 4.7 x $10^4$ | 0.106 |
| 22.75 | 0.167 | 0.036 | 2,100 | 900 | 3,000 | 3.4 x $10^4$ | 0.088 |
| 26.00 | 0.125 | 0.008 | 1,570 | 200 | 1,770 | 2.6 x $10^4$ | 0.066 |
| 29.25 | 0.076 | - | 960 | - | 960 | 2.1 x $10^4$ | 0.040 |
| 32.50 | 0.039 | - | 490 | - | 490 | 1.75x $10^4$ | 0.025 |
| 35.75 | 0.015 | - | 190 | - | 190 | 1.5 x $10^4$ | 0.013 |
| 39.0 | 0.005 | - | 60 | - | 60 | 1.35x $10^4$ | 0.004 |
| Σ | 1.00 | 1.00 | 12,600 | 25,000 | 37,600 | | 0.544 |

Thus, for Σ (n/N) = 1: $\frac{1000}{0.544}$ = 1840 landings and takeoffs required

or $\frac{37,600}{0.544}$ = 69,100 cycles required

this case, the fatigue loading involves a relatively great number of cycles of stress at a rather low stress level. To attack the problem properly, the following data are required:

(1) The nature of the loadings actually experienced in service (the magnitude and the number of pressure cycles).

(2) The fatigue strength of the plating.

Then a method must be devised for analyzing data so that a solution can be formulated.

In 1955, a seaplane instrumented with a series of pressure pickups on the hull bottom made about 50 landings and take-offs in the open sea. The data revealed that the pressure variations at each location could be represented by normal probability distribution curves.[2] These are shown in Figs. 4 and 5. The average and peak pressures are higher in landing than in take-off, but there are about twice as many pressure occurrences during take-off. This constitutes the applied load spectrum.

### Fatigue Strength

As a result of a rather broad investigation in which 270 small specimens and a dozen large panel specimens were tested, the fatigue strength of the specified hull bottom structural configuration was determined.[1] These data are shown in Fig. 6 as maximum cyclical plating pressure vs. number of cycles to failure. The solid line is the log mean value, which expresses the 50/50 chance of failure for a specimen cycled at a constant maximum pressure level. The dashed lines represent the scatter band. The scatter distribution is considered log normal. Hence the no-failure probability at any stress or pressure level can be determined from the relation

$$\log N_1 = \log \bar{N} + x\sigma$$

where

$N_1$ = cycles to failure at a particular desired probability
$\bar{N}$ = mean cycles to failure
$\sigma$ = standard deviation of the fatigue strength scatter
$x$ = number of standard deviations to acquire the desired no-failure probability, as determined from Fig. 7

(All logs used here are to the base 10.)

Thus we have the allowable fatigue strength in probability form.

### Damage Study

To determine, with some degree of confidence, the number of landings and take-offs that can be made without failure, a damage study can be made comparing the applied pressure load spectrum with the allowable fatigue strength of the bottom structure. This is done using Miner's cumulative damage theory. A sample calculation is shown in Table 1, in which the fatigue damage is determined for 1,000 landings and take-offs using a severity factor (SF) equal to 0.65.

The SF factor is assumed and is intended to represent the ratio of the plating pressure in normal fleet utilization to the actual pressure measured during the tests of the instrumented airplane (defined by Figs. 4 and 5). The frequency percentage for each pressure interval (in this example, multiplied by 0.65) for landing and take-off is recorded in columns 2 and 3, respectively. Columns 4 and 5 show the actual number of cycles at landing ($N_L$) and take-off ($N_{TO}$), and column 6 gives the total at each interval ($N_T$). The log mean fatigue strength ($N_m$) is recorded in column 7 from Fig. 6. Miner's theory is applied in column 8, which shows the fatigue damage at each pressure interval. The summation of $n/N$ indicates that, for 1,000 take-offs and landings, total damage is 0.544. For actual failure, $\Sigma(n/N)$ must be equal to 1. Under these circumstances, one could expect a 50 per cent probability of making (1,000/0.544) = 1,840 landings and take-offs without a failure.

For any other probability, the number of landings and take-offs can be determined by using the relationship given above and shown in Fig. 7. In this case, for a 95 per cent probability

$$\log N_1 = \log \bar{N} + x\sigma$$
$$\bar{N} = 69{,}100 \text{ (Table 1)}$$
$$\log \bar{N} = 4.840$$

where

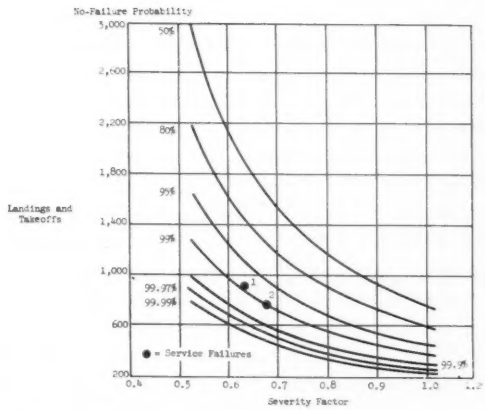


Fig. 8. No-failure probability (0.080 hull bottom plating).

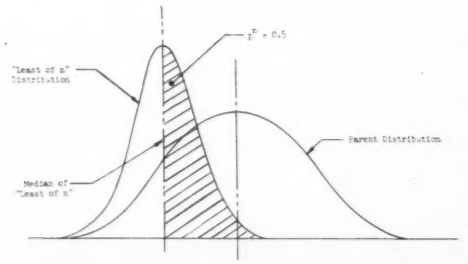


Fig. 9. "Least of n" distribution.

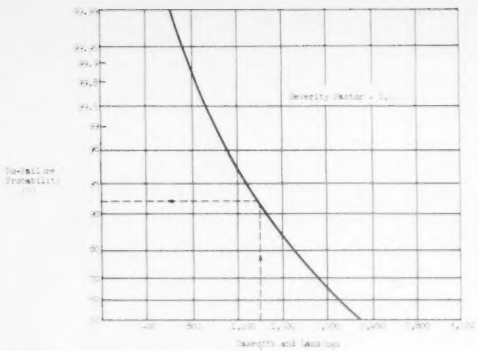

Fig. 10. No-failure probability (0.080 skin).

$\sigma$ = standard deviation = 0.146 (derivation not shown)

$x$ = $-1.65$ (see Fig. 7)

$$\text{Therefore} \quad \log N_1 = 4.840 - 1.65 \times 0.146$$
$$= 4.600$$
$$N_1 = 39{,}800 \text{ cycles}$$

and 1,000 × (39,800/37,600) = 1,060 landings and take-offs with a 95 per cent probability.

By similar tabulations and calculations, the no-failure probability for Severity Factors ranging from 0.5 to 1 and for other probabilities is determined (see Fig. 8). Now, from the fact that actual failures have occurred, it becomes possible to estimate the actual Severity Factor. This is accomplished by reviewing all the airplanes of the fleet with regard to the number of actual landings and take-offs each has made. Knowing this, as well as the number of landings and take-offs made by the airplanes which have encountered the failures in service, the Severity Factor can be established by use of "least value statistics." This is defined as $P^n = 0.5$ (see Fig. 9).

In this relationship, $P$ is the probability and $n$ is the number of aircraft which have equalled or exceeded the number of landings and take-offs made by the failure airplanes. It is assumed that the failure airplane represents the median of the "least of $n$" lives of all possible groups of $n$ airplanes. By solving for $P$, a significant Severity Factor can be approximated for each case of failure by plotting points on the general plot of probability vs. severity factors.

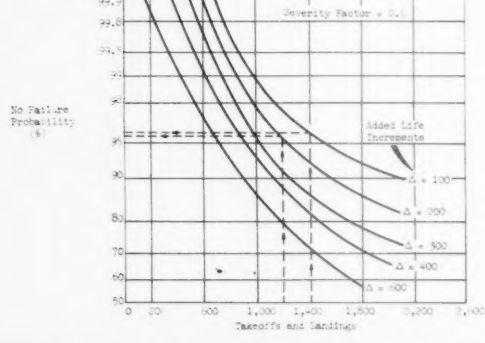


Fig. 11. No-failure probability for incremental lives.

## Examples

### *Failure 1*

When this ship failed, it had made 932 take-offs and landings. Thirty-four other aircraft had equalled or exceeded this number of landings and take-offs. Then

$$P^{34} = 0.50$$
$$34 \log P = 9.69897 - 10$$
$$P = 0.98$$

which implies that, if the probability of each aircraft to survive 932 landings and take-offs is 98 per cent, then there is an even chance that all but one of 34 aircraft will survive 932 landings and take-offs.

### *Failure 2*

Seventy-eight airplanes had made 786 or more landings and take-offs at the time of this failure. Then

$$P^{78} = 0.5$$
$$78 \log P = 9.69897 - 10$$
$$P = 0.99$$

the probability of each aircraft to survive 786 landings and take-offs.

By plotting these probability values in Fig. 8, it becomes possible to establish a severity factor which has the effect of correlating the load spectrum data obtained during test with the loading occurring during actual service conditions. Included in this Severity Factor is a factor which compensates for any discrepancy that might have been incurred by assuming $\Sigma(n/N) = 1$. Thus, for the cases cited, the Severity Factor must lie between 0.6 and 0.7.

Shown in Fig. 10 is a cross-plot of Fig. 8 at a Severity Factor of 0.6. Here no-failure probability is plotted against life in terms of take-offs and landings. For example, the no-failure probability for 1,400 landings and take-offs is 92 per cent. Fig. 10 is satisfactory from an academic standpoint, but, without some knowledge of how to apply it, the information would be of little use to personnel engaged in actual operation and maintenance of the aircraft. By applying the following relationship, the information can be put into the much more useful form of Fig. 11:

$$P_{(N + \Delta N)}/P_N = P_{\Delta N}$$

where

$P_N$ = probability at lifetime zero to survive a certain life $N$ (read from Fig. 10)

$P_{(N+\Delta N)}$ = probability at lifetime zero to survive a life equal to $N$ plus an increment of life $\Delta N$ (read from Fig. 10)

$P_{(\Delta N)}$ = probability of $\Delta N$ after having completed life $N$

With Fig. 11, it is possible to ascertain the no-failure probability for continuing an airplane in service for a particular period of time, when the number of previous landings and take-offs is known. It is to be understood of course, that the airplane under consideration has been inspected and found free of any failure.

The notations on Fig. 11 show, for example, that after 1,200 landings and take-offs, the probability of successfully completing an additional 200 landings without failure in the hull bottom plating is 95.5 per cent. The value of this relationship is evident by comparison with the probability of 92 per cent at lifetime zero, shown in Fig. 10. Also, Fig. 11 shows that even after 1,400 successful take-offs and landings, there still exists a 96 per cent probability of successfully completing an additional 100 take-offs and landings.

### References


[1] *A Study of the Fatigue Life and Structural Behavior of Seaplane Hull Bottom Plating*, Martin Engineering Report 6659, April, 1955.

[2] *Analysis of Acceleration and Water Pressure Data Obtained on a P5M-2 in Moderately Rough Water*, Martin Engineering Report 9918, March, 1958.


✦ ✦ ✦

## The Pilot's Role in Space Flight (Continued from page 54)

This is not an easy job, but one in which man's adaptability and versatility are shown to best advantage. In deciding whether the expected landing site is satisfactory or whether some other position must be selected, human judgment will be almost indispensable. If it is expected that a return flight from the moon will be made, the problems in designing a system able to do this automatically and allow for all contingencies with a reasonable probability of success are almost beyond comprehension.

For re-entry into the atmosphere, the type of re-entry vehicle must be considered before comments can be made about the possible contribution of man. In the ballistic re-entry, the pilot would have little or no function other than possibly correctly orienting the vehicle at the initiation of re-entry. In the lifting vehicle type re-entry, the pilot with proper displays may well be able to control the vehicle through the complete re-entry, thereby simplifying the control system.

The final phase of approach and landing is the nearest to present piloting. Vehicle configurations will no doubt be radical, introducing new dynamic characteristics. However, such a task is within man's capabilities. An automatic system to perform such an approach and landing is feasible; therefore, this phase, as with some others, cannot show an overriding reason for man in space. It merely shows some possible applications if he is along for the ride for other reasons.

### Conclusions

To summarize, we may state that certain functions *must* be performed automatically. These include those actions requiring a fast reaction time or response to an environment which is unfavorable for the pilot. These include most actions in the boost and certain re-entry trajectories. Certain functions *might best* be done automatically. Included in these would be continuous, long time, repetitive and boring actions in which the pilot's attention may wander and his performance suffer. This would include continuous, tight attitude stabilization in space flight.

Performance of certain projected military space missions, nebulous though they may be, will require judgment characteristic only of man. Certain difficult tracking and judgment tasks, such as moon landing, are especially suitable for him. Finally, the use of man to eliminate some of the complexity of the control system and to perform repair of the remaining equipment *will be required* to make feasible extended space missions.

Once the need for man is established for a given mission either as a flight control element or for another reason, the whole mission must be examined to determine where he can be used. Highly desirable reductions in weight of equipment and increases in probability of success will result from this approach.

It is concluded that man has a place in certain missions not merely on the basis of curiosity or even scientific observation, but on *sound engineering reasons* as a flight control element.

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[1] Krendel, E. S., *The Mechanical Power Output of Man*, Franklin Institute TR F-A1982, January, 1958.

[2] McRuer, D. T., and Westbrook, C. B., *Handling Qualities and Pilot Dynamics*, Aero/Space Engineering, Vol. 18, No. 5, pp. 26–32, May, 1959.

[3] McRuer, D. T., and Krendel, E. S., *Dynamic Response of Human Operators*, Control Specialists and Franklin Institute, WADC TR 56-524, October, 1957.

[4] Anderson, R. O., *Design for Space Vehicle Control System Reliability*, WADC TN 58-156, April, 1958.

[5] Anderson, R. O., *Methods of Analyses for Space Vehicle Control System Redundancy*, WADC TN 58-346, December, 1958.


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***The Checkout that says "GO" or "NO GO"***

# APCHE

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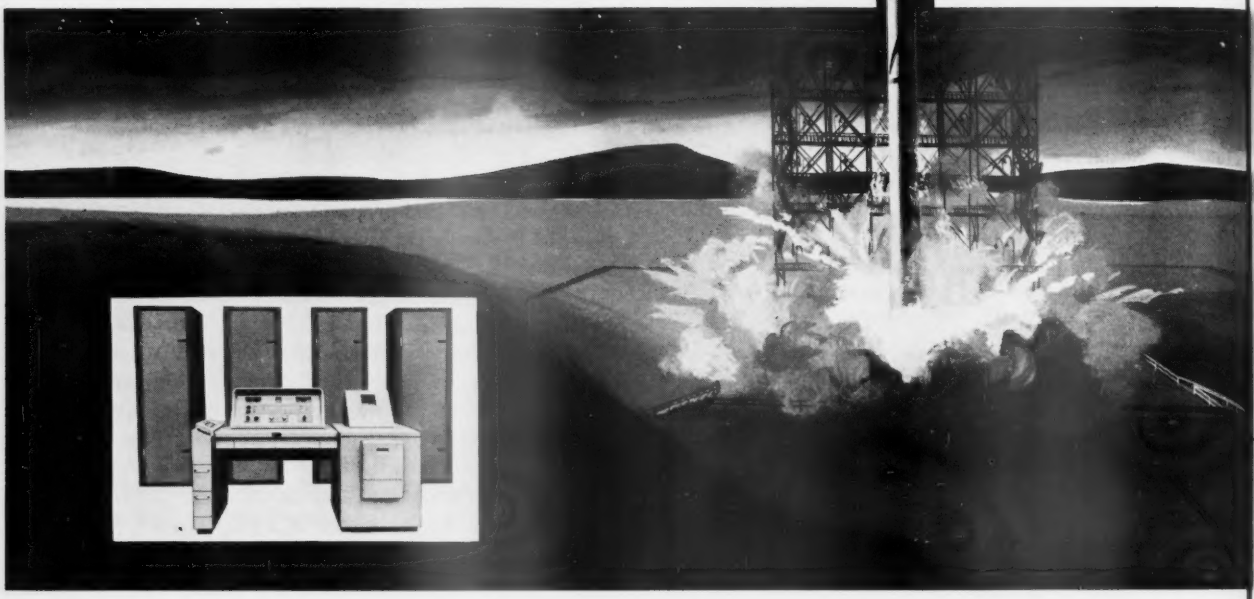

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The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

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## Acoustics, Sound, Noise

**Noise in the Jet Age.** H. R. Broadbent. *Flight*, Aug. 14, 1959, pp. 10, 11. Discussion of the noise problem as it affects residents around airports, and of the problem of defining a noisiness parameter.

**Contribution à l'Etude des Ultrasons Aériens: Production et Applications.** Raymond Boucher. *France, Min. de l'Air NT 79*, 1958. 134 pp. 116 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 2,548. In French. Study of the relation between various aerodynamic forms of supersonic jet streams and their types of acoustic emissions. A description of the utilization of air ultrasonics in industry is also included.

**K Voprosu o Printsipe Vzaimnosti v Akustike.** L. M. Liamshev. *AN SSSR Dokl.*, Apr. 21, 1959, pp. 1,231–1,234. In Russian. Mathematical formulation of the reciprocity principle in acoustics describing the relationship between volume sources; certain external forces acting upon shells, membranes, and elastic plates; and radiation fields generated by these sources and bodies.

**Noise Generated by Two Interacting Air Jets.** Uno Ingard and G. C. Maling, Jr. *ASA J.*, July, 1959, pp. 1,031–1,033. USAF-Army-Navy-supported evaluation of the measurement of interaction noise produced by jets lying in the same plane, for jet intersection angles between 0° and 180°. The case of two jets intersecting at a 90° angle but lying in different planes is also considered.

**Noise Reduction in Air Force Control Towers.** R. J. Christman. *Noise Control*, July, 1959, pp. 24–29, 55.

**Intrusion of Aircraft Noise into Communities Near Two USAF Air Bases.** W. E. Clark and A. C. Pietrasanta. *USAF WADC TN 58-213 [AD 212223]*, Feb., 1959. 222 pp. 26 refs.

**Distribution of Sound Sources in a Jet Stream.** Ira Dyer. *ASA J.*, July, 1959, pp. 1,016–1,022. Derivation of an approximate axial distribution of noise sources in a turbulent jet stream in terms of the spectrum of the total radiated power and the frequency of the sources as a function of location along the axis.

**Aviones y Decibeles.** N. E. Strasser. *Rev. Nac. Aero.*, Feb., 1959, pp. 50–53. In Spanish. Report on the activities of the aircraft industry in the field of reduction of noise produced by jet engines.

**Some Near- and Far-Noise Measurements for Rocket Engines Operating at Different Nozzle Pressure Ratios.** W. H. Mayes. (*ASA 55th Meeting, Wash., May 7–10, 1958.*) *ASA J.*, July, 1959, pp. 1,013–1,015. Presentation of results of measurements on a 1,650-lb. thrust engine and 6,000 to 7,500-lb. thrust engines with varying jet exit flow conditions in order to study their effects on the noise level and spectra.

**Considerations Concerning an Upper Limit to Jet Noise Reduction.** Alan Powell. *ASA J.*, Aug., 1959, pp. 1,138–1,140. Study concluding that maximum practically realizable power level reduction (in decibels) is about half of the upper limit.

**SAAB Silencer System.** N. O. Olesten. *Noise Control*, July, 1959, pp. 15–20. Description of a silencer system for ground testing of jet aircraft.

**Methods for Estimating Distributions and Intensities of Sonic Bangs.** D. G. Randall. *Gt. Brit., ARC R&M 3113* (Aug., 1957) 1959. 32 pp. BIS, New York, $2.07.

## Aerodynamics, Fluid Mechanics

### *Aerothermochemistry, Dissociation, Ablation*

**How Far Are we on Re-Entry Cooling?** K. R. Stehling. *Space/Aeronautics*, Sept., 1959, pp. 43–45. Review of re-entry cooling including such techniques as ablation, sublimation, heat sinks, heat of fusion and solution, and regenerative cooling. Basic elements of each process are explained, and the suitability of various materials is discussed.

**An Experimental and Theoretical Study of Quartz Ablation at the Stagnation Point.** M. C. Adams, W. E. Powers, and Steven Georgiev. *Avco Everett Res. Lab. RR 57*, June, 1959. 33 pp. 10 refs. USAF-sponsored investigation of clear and opaque quartz. The energy absorbed per unit mass ablated is measured over a range of simulated flight conditions and data are compared with theory. It is shown that opaque quartz will absorb about 4,000 B.t.u./lb. for ICBM and IRBM trajectories and will radiate the aerodynamic heating, with negligible ablation, for a satellite trajectory.

**On the Stable Shape of a Slender Ablating Graphite Body.** G. W. Sutton. *J. Aero/Space Sci.*, Oct., 1959, pp. 681, 682. USAF-supported calculation of the terminal shape of a graphite rod assuming the burning graphite to form CO at the surface.

### *Aerothermodynamics*

**Study of the Thermal Problems Encountered in Flight at Supersonic Speeds; Introduction to Aerodynamic Heating.** J. C. Gomez. *Gt. Brit., MOS TIL/T4948*, Nov., 1958. 18 pp. 28 refs. Translation. Presentation of relations for calculating stagnation, kinetic, and equilibrium temperatures, including a discussion of heat transfer and protection of the structure.

**Analysis of the Aerodynamic Heating for a Re-Entrant Space Vehicle.** M. J. Brunner. (*ASME Av. Conf., Los Angeles, Mar. 8–12, 1959, Paper 59-Av.5.*) *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 223–229. Study made for both laminar and turbulent boundary layers considering real gas and compressibility effects. Zero- and high-lift vehicles traveling over two different trajectories are covered in the analysis. The maximum heating rates and time-integrated heat fluxes are given as functions of the local pressure distribution, body geometry, and wall temperature.

**On the Temperature Distribution Behind Cylinders in a Flow.** Jakob Ackeret. (*ETH Inst. Aerodynamik, Mitteil. No. 21*, 1954.) *U.S., NASA TT F-2*, Aug., 1959. 18 pp.

**Heat Transfer and Recovery Factor in a Laminar Boundary Layer with Arbitrary Pressure Gradient and Wall Temperature Distribution.** Bernard Le Fur. *J. Aero/Space Sci.*, Oct., 1959, pp. 682, 683.

**Calculation by the Integral Method of the Effect of Fluid Injection Upon an Isothermal Boundary Layer.** M. M. Klein. *J. Aero/Space Sci.*, Oct., 1959, pp. 686, 687. USAF-supported research.

**Some Experimental Techniques in Mass Transfer Cooling.** B. M. Leadon. *Aero/Space Engrg.*, Oct., 1959, pp. 28–32, 99. 44 refs. Discussion of various methods of coolant injection into an exterior boundary layer of hot gas, emphasizing mass transfer cooling where the mass diffusion is found to be a major factor in the behavior of the boundary layer.

**Optimum Magnetic Field for Stagnation Heat Transfer Reduction at Hypersonic Velocities.** Robert Goulard. *ARS J.*, Aug., 1959, pp. 604, 605.

**Comments on "On Slip-Flow Heat Transfer to a Flat Plate."** D. E. Nestler. *J. Aero/Space Sci.*, Oct., 1959, pp. 687, 688. Study showing that the effect of slip on boundary-layer thickness is not negligible and that the Reynolds analogy holds reasonably well in the slip-flow regime.

**Über die Möglichkeit der Verdampfung von in die Erdatmosphäre eintauchenden Raketen oder Satelliten.** W. Strubell. *Weltraumfahrt*, Mar., 1959, pp. 17, 18. In German. Discussion of the possibility of evaporation of rockets or satellites during re-entry into the earth's atmosphere.

**A Diffusion Problem with Chemical Reaction.** H. A. Lauwerier. *Appl. Sci. Res., Sect. A*, No. 5, 1959, pp. 366–376. Analysis of the stationary state of a substance subjected to cylindrical Poiseuille flow, diffusion, and a chemical reaction. The problem is reduced to an orthogonal set of eigenfunctions.

### *Boundary Layer*

**Thermal Boundary Layer on a Rotating Disc.** L. A. Dorfman. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 248–251. Translation. Derivation of the equations for turbulent motion in an incompressible liquid.

**Perekhod Turbulentnogo Pogranichnogo Sloia v Laminarnyi.** A. A. Sergienko and V. K. Gretsov. *AN SSSR Dokl.*, Apr. 1, 1959, pp. 746, 747. In Russian. Experimental investigation of boundary layer transition showing the presence of a reverse transition from turbulent to laminar in the case of large negative pressure gradients in the supersonic nozzle.

**The Compressible Laminar Boundary Layer with Arbitrary Pressure Gradient and Wall Temperature Distribution.** J. C. Williams, III. *J. Aero/Space Sci.*, Oct., 1959, pp. 677, 678. AFOSR-supported research.

### *Flow of Fluids*

**Approximate Subsonic Gas Flows Under Assigned Boundary Conditions.** G. Power and P. Smith. *Appl. Sci. Res., Sect. A*, No. 5, 1959, pp. 349–356. 12 refs. Discussion of the solution to compressible flow problems under fully assigned boundary conditions. It is shown that Schwarz's results on minimal surfaces can be immediately applied for two-dimensional flow. Several special examples are considered.

**Dozvukovoe Obtekanie Ellipsov s Tsirkuliatsiei.** P. I. Chushkin. *AN SSSR Dokl.*, Apr. 1, 1959, pp. 748–751. In Russian. Application of a previously developed numerical method to the calculation of flow with circulation around an ellipse.

**The Estimation of Shock Pressure Recovery and External Drag of Conical Centre-Body Intakes at Supersonic Speeds.** Appendix I—Calculation of the Conditions at the Intersection Point of Three Shocks with Resultant Subsonic Flow. Appendix II—The Method of Estimating the Position of the Detached Shock Wave in Front of Pitot and Centre-Body Intakes at Any Mass Flow. Appendix III—A Method of Calculating the Pressure Recovery when $r_i$ is Greater than $r_\infty$. Appendix IV—The Method of Calculating Cowl Drag at Full Mass Flow. Appendix V—The Calculation of External Drag Coefficient, $C_D$ *ext*, under Spillage Conditions. E. L. Goldsmith and C. F. Griggs. *Gt. Brit., ARC R&M 3035* (Nov., 1953) 1959. 66 pp. 12 refs. BIS, New York, $4.05.

**Shroud Tests of Pressure and Heat Transfer Over Short Afterbodies with Separated Wakes.** M. H. Bloom and Adrian Pallone. (*Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech. Rep.*, June, 1958.) *J. Aero/Space Sci.*, Oct., 1959, pp. 626–636, 662. 11 refs.

**Prisoedinenie Massy Nekotorykh Krivolineinykh Konturov, Obtekaemykh s Otryvom Strui.** S. I. Parkhomovskii. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 585–588. In Russian. Study of the impact problem for a family of curves in the case of infinite flow of an ideal incompressible liquid with separation.

**The Speed Barrier—Its Nature and Some of the Problems of Hypersonic Flight.** W. H. Wittrick. *Aircraft* (Australia), July, 1959, pp. 30, 31, 34, 56. Discussion of the origin of kinetic heating, molecular phenomena, heat transfer, creep buckling, and loss of stiffness due to thermal stress.

**Ob Ustoichivosti Ellipsoidov Maklorena Vrashchaiushcheisia Zhidkosti.** V. V. Rumiantsev *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 494–504. In Russian. Derivation of a solution for the stability of Maclaurin ellipsoids for the case of rotating liquids when the initial perturbations satisfy Dirichlet hypotheses.

**Nonstationary Flow with Heat Transfer in a Viscous, Incompressible Fluid Between Two Revolving Discs Accompanied by Fluid Influx.** G. A. Tirskii. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 237–239. Translation.

**Magnetohydrodynamics—A Survey of the Literature.** O. K. Mawardi. *Appl. Mech. Rev.*, July, 1959, pp. 443–446. 58 refs.

**Magnetic Boundary Layers.** H. F. Ludloff. *ARS J.*, Aug., 1959, pp. 590, 591. Analysis of the influence of a magnetic field on the velocity profile of a thin airfoil. The transformation of an originally axisymmetric field into a thin, long, magnetic boundary layer due to the action of a strong wind can then be described.

**On the Concepts of Moving Electric and Magnetic Fields in Magnetohydrodynamics.** J. E. McCune and W. R. Sears. *J. Aero/Space Sci.*, Oct., 1959, pp. 674, 675. Discussion of the concept of "moving magnetic fields" in order to clarify its use by some authors.

**Ionic Theory of Plasmas and Magnetohydrodynamics.** H. S. Green. *Phys. Fluids*, July-Aug., 1959, pp. 341–349. 15 refs. Derivation of a complete set of macroscopic equations based on ionic theory.

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**On the Flow Past a Sphere at Hypersonic Speed with a Magnetic Field.** N. C. Freeman. *J. Aero/Space Sci.*, Oct., 1959, pp. 670–672; Author's Reply, N. H. Kemp, p. 672.

**Selected Topics from the Theory of Gas Flow at High Temperatures. VI—Some Aspects of Particle Interaction in Gases.** J. M. Burgers. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-176* (*AFOSR TN 59-631*), June, 1959. 40 pp. Study of three examples of particle interaction in gases: (a) reactions taking place at close binary encounters; (b) collisions between charged particles treated with the aid of a two-particle distribution function; (c) electric fields which appear when there are differences in positive and negative charge densities.

**On Motions with Homogeneous Deformation in Magneto-Hydrodynamics.** A. G. Kulikovskii. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 507–509. Translation. Presentation of a class of solutions for flow in a viscous medium of finite electrical conductivity.

**Plasma Radiation in a Magnetic Field.** B. A. Trubnikov. *Sov. Phys. - Dokl.*, Jan.-Feb., 1958, pp. 136–140. Translation. Theoretical analysis of plasma radiation due to the revolutionary motion of electrons in a uniform magnetic field; only the high harmonics are considered.

**High Speed Flow Through Wire Gauzes.** P. G. Morgan. *RAeS J.*, Aug., 1959, pp. 474–475. Investigation showing the need for consideration of Reynolds Number and Mach Number effects on the pressure drop coefficient. The solidity ratio of the gauze is an insufficient criterion for estimating the pressure loss at high Mach Number flows, and a further investigation of this factor is necessary.

**On a Generalized Porous-Wall "Couette-Type" Flow.** G. M. Lilley. *J. Aero/Space Sci.*, Oct., 1959, pp. 685, 686. Solution of a

problem solved previously by Cramer, using, in this case, a different interpretation to one of the parameters.

**O Metodă Aproximativă Pentru Studiul Scurgerii Spre Sonde in Mediu Poroase Neomogene.** Teodor Oroveanu. *Stud. Cerc. Mec. Aplic.*, No. 1, 1959, pp. 87–108. In Rumanian, with summaries in Russian and French. Development of an approximate method to study the flow of an incompressible fluid through an isotropic porous, but nonhomogeneous, medium.

**Graphical Computation of Shock and Detonation Waves in Real Gases.** G. H. Markstein. *ARS J.*, Aug., 1959, pp. 588–590. ONR-supported presentation of the conservation relations across a shock or detonation wave in the form of a graph applicable to real gases of arbitrary composition. Computation of shock waves reflected from a closed end is performed by means of another universally applicable graph.

**Shock Waves in Media with Arbitrary Equations of State.** G. Ia. Galin. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 244–247. Translation. Analysis of abrupt discontinuities in media whose interval energies are completely defined by specific volume and entropy.

**Low-Density Research.** J. B. French, E. O. Gadamer, S. A. Gordon, and E. P. Muntz. *Shell Av. News*, June, 1959, pp. 14–17. Discussion of UTIA's facilities for low-density research and of some preliminary results.

**Zamechanie k Dokladu A. Ferri "Novaa Teoreticheskaia Rabota po Sverkhzvukovoi Aerodinamike v Bruklinskom Politekhnicheskom Institute."** B. M. Bulakh. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 576–580. In Russian. Evaluation of Ferri's theoretical results on conical flows occurring at high Mach Numbers in the case of strong perturbations generated by the body. The existence of intermediate transonic regions adjacent to the Mach cone in supersonic flow around triangular conical wings is studied.

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**On the Eddy Diffusivities for Momentum and Heat.** C. L. Tien. *Appl. Sci. Res., Sect. A*, No. 5, 1959, pp. 345–348. Development of a universal, semiempirical expression for the eddy diffusivities in a turbulent shear flow in terms of the distance from the solid boundary and the flow properties.

**An Experimental and Analytical Study of Vortex-Flow Temperature Separation by Superposition of Spiral and Axial Flows. I, II.** J. E. Lay. (*ASME Semi-Annual Meeting, Detroit, June 15–19; Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Papers 58-SA-71; 58-A-90.*) *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 202–221; Discussion, pp. 211, 212, 221, 222. 41 refs. Investigation conducted in order to clarify the Ranque-Hilsch effect and to extend the knowledge of vorticity in general.

**Ob Asimptotike Osesimmetrichnoi Raskhodiashcheisia Volny v Tiazheloi Zhidvosti.** S. V. Iordanskii. *AN SSSR Dokl.*, Apr. 21, 1959, pp. 1,211–1,214. In Russian. Study of the asymptotic character of axisymmetric waves propagating in a heavy liquid at large distances from the axis of symmetry.

### *Internal Flow*

**Determination of the Angular Velocity of Rotating Stall in an Axial Flow Machine by Noise and Vibration Analysis.** A. L. Jaumotte. (*Journées Internatl. Sci. Aéro., Paris, May, 1957.*) *Muirhead Tech.*, Apr., 1958, pp. 14–16.

**Untersuchungen über den Ventilationsverlust von Turbinenrädern.** Peter Suter and Walter Traupel. *ETH Inst. therm. Turbomasch., Mitteil. No. 4*, 1959. 39 pp. In German. Presentation of experimental results on losses in turbine wheels, covering the following aspects: description of test equipment, accuracy of measurements, investigation of flow for different blade arrangements, and the effect of the Reynolds Number.

**Wakes in Axial Compressors.** H. Pearson and A. B. McKenzie. *RAeS J.*, July, 1959, pp. 415, 416. Discussion showing that flow into and through a compressor must be approximately at constant velocity, but not quite, the wake being slightly less than that of the main flow.

**Experimentelle Untersuchungen an geraden und gekrümmten Diffusoren.** Herbert Sprenger. *ETH Inst. Aerodynamik, Mitteil. No. 27*, 1959. 84 pp. 44 refs. In German. Experimental investigation on straight and curved diffusers in order to determine the effect of the frictional boundary layer on incompressible flow in channels with pressure rise along the axis. The wall pressure and energy distributions at the outlet are studied, and data on the local pressure conversion are presented.

**Shock Waves and Dissipation in a Resonance Tube.** A. H. Shapiro. *J. Aero/Space Sci.*, Oct., 1959, pp. 684, 685.

**Stability Considerations on Nonviscous Jets Exhibiting Surface or Body Tension.** Peter Debye and Jerome Daen. *Phys. Fluids*, July-Aug., 1959, pp. 416–421. Army-supported analysis of a nonviscous sheet and cylinder which exhibit surface or body tensions, neglecting any fluid viscosity.

**A Study of the Initial Section of a Turbulent Jet of Compressed Gas.** Sh. A. Ershin and Z. B. Sakipov. *Sov. Phys. - Tech. Phys.*, Jan., 1959, pp. 43–51. Translation. Investigation of the laws of propagation of turbulent jets of gas in a medium of different density, using both isothermal jets (heated as compared with the surrounding medium) and isothermal mixing of a jet of hydrogen with atmospheric air.

**Evaluation of Conical Nozzle Thrust Coefficient.** G. V. R. Rao. *ARS J.*, Aug., 1959, pp. 606, 607.

### *Performance*

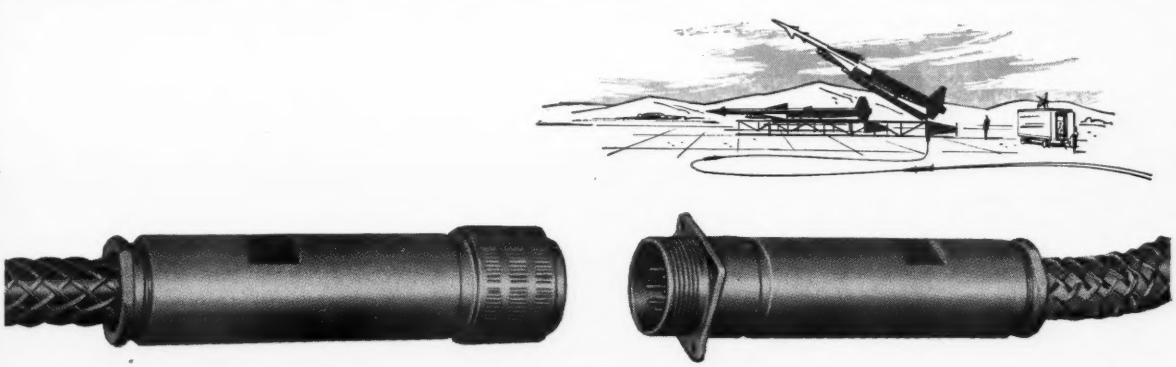
**Un Exemple de la Détermination des Principaux Coefficients Aérodynamiques à Partir des Essais en Vol.** G. Leblanc. (*NATO AGARD Flight Test Panel Meeting, Paris, Apr., 1958.*) *NATO AGARD Rep. 189*, Apr., 1958. 23 pp. In French. Study showing that it is possible to obtain the more important aerodynamic coefficients from a limited number of simple flight tests, and thus enable an assessment to be made of the performance and handling qualities of an aircraft at the prototype stage.

**The Influence of Drag Characteristics on the Choice of Landing Approach Speeds.** D. Lean and R. Eaton. *Gt. Brit., ARC CP 433* (Apr. 1957) 1959. 26 pp. BIS, New York, $0.72.

### *Stability & Control*

**On the Extraction of Stability Derivatives from Full-Scale Flight Data.** J. K. Zbrozek. (*Gt. Brit., RAE TN Aero.2559*, Apr., 1958.) *NATO AGARD Rep. 190*, Apr., 1958. 27 pp.

**Despre Stabilitatea Longitudinală a Avionului in Cazul Perturbaţilor Repetate.** Tiberiu Hacker. *Stud. Cerc. Mec. Aplic.*, No. 1, 1959, pp. 69–76. In Rumanian, with summaries in Russian and French. Presentation of a method of calculation, based on the direct method developed by Liapunov, for determining the longitu-

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dinal stability of an aircraft during repeated perturbations. Suggestions for the improvement of aircraft stability are made.

### *Wings & Airfoils*

**An Estimate of the Suction Peak on Infinite Sheared Wings.** J. Weber. *RAeS J.*, Aug., 1959, pp. 476, 477. Derivation of a relation between the minimum pressure coefficient and nose radius of an infinite sheared wing with symmetrical sections.

**The Formation of Regions of Separated Flow on Wing Surfaces. I—Low-Speed Tests on a Two-Dimensional Unswept Wing with a 10 per cent Thick RAE 101 Section. II—Laminar-Separation Bubbles and the Mechanism of the Leading-Edge Stall.** L. F. Crabtree. *Gt. Brit., ARC R&M 3122* (July, 1957) 1959. 28 pp. 34 refs. BIS, New York, $1.80.

**On the Stability of Elastic Plates in a Supersonic Stream.** Dun Min-De. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 479–483. Translation. Calculation of the aerodynamic pressure over the surface of the plate by the Cauchy-Lagrange equation for oscillating wings of infinite span, taking into account the compatibility conditions of oscillations of an elastic plate and a gaseous medium in the immediate vicinity of its surface.

**Skos Potoka za Strelovidnym Vikhrem Konechnogo Razmakha pri Neustanovivshemsia Dvizhenii.** E. A. Biriukov. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 583, 584. In Russian. Derivation of formulas leading to a method for the calculation of the flow slope in an ideal incompressible fluid behind a wing having a high aspect ratio and a small angle of sweepback. The study covers the case when the circulation varying with the wing span also harmonically varies with time.

**Wing of Finite Span with a Symmetrical Profile in Compressible Flow.** E. A. Krasil'shchikova. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 475–478. Translation. Analysis of a thin wing at zero angle of attack for the arbitrary motion at both subsonic and supersonic speeds.

**Asupra unor Formule de Recurență Referitoare la Calculul Coeficienților Vitezei Axiale de Perturbație Pentru Mișcările Omogene de Ordin Superior.** Adriana Năstase. *Stud. Cerc. Mec. Aplic.*, No. 1, 1959, pp. 241–248. In Rumanian, with summaries in Russian and French. Presentation of an algorithm for calculating the coefficients of axial turbulent velocity for a thin symmetrical triangular wing in supersonic flow.

## Aeroelasticity

**Caracteristicile Aerodinamice ale Aripioarelor Avînd o Mișcare Oscilatorie Armonică în Regim Supersonic.** Elie Carafoli and Șerban Săndulescu. *Stud. Cerc. Mec. Aplic.*, No. 1, 1959, pp. 13–40. In Rumanian, with summaries in Russian and French. Study of aerodynamic characteristics of ailerons subject to harmonic oscillatory motion at supersonic speeds. It is found that the oscillatory motion of a polygonal aileron is equivalent to that of two triangular surfaces and that all forms of ailerons can be calculated by means of a specifically developed equation.

**The Effect of Configurational Additions Using Viscoelastic Interfaces on the Damping of a Cantilever Beam.** J. S. Whittier. *USAF WADC TR 58-568 [AD 214381]*, May, 1959. 59 pp. 11 refs. Calculation of optimum values of viscoelastic damping and comparison with calculated values of damping due to hysteresis of the structural material of a beam.

**The Aerodynamic Effects of Aspect Ratio on Control Surface Flutter.** H. Hall and E. W. Chapple. *Gt Brit., ARC CP 434* (Sept., 1957) 1959. 16 pp. BIS, New York, $0.45.

**An Alternative Formulation of the Problem of Flutter in Real Fluids.** Wen-Hwa Chu and H. N. Abramson. *J. Aero/Space Sci.*, Oct., 1959, pp. 683, 684. 12 refs. Study showing the necessity of replacing the Kutta-Joukowski condition by other criteria for flutter calculations under certain conditions.

**Power-Spectral Analysis Gives Better Gust Load Data.** T. A. Siciliano and W. J. Oakes. *Space/Aeronautics*, Sept., 1959, pp. 49–53. Application of statistical concepts to the problem of gust-load determination. Transfer function and direct methods for finding turbulence spectra are described.

**Atmospheric Turbulence Encountered by Super Constellation Aircraft.** J. R. Heath-Smith. (*Gt. Brit., RAE TN Struc.257*, Jan., 1959.) *Gt. Brit., ARC CP 432*, Jan., 1959. 33 pp. BIS, New York, $0.90. Test results indicating that below 10,000 ft. the frequency of gusts exceeding 10 ft./sec. is less over sea than over land by a factor of at least two. There is evidence from four geographical regions of a single fluctuation of turbulence during the year, the phase depending to some extent on longitude.

**A Remark Concerning the Vibration of a Delta Wing in Supersonic Flight.** M. M. Stanišić. *J. Aero/Space Sci.*, Oct., 1959, pp. 679–681. Analysis showing that the velocity potential is an inconvenient method for formulating an integral equation to govern delta wing vibrations.

**Power Spectral Density Nomogram.** R. W. Mustain. *Environmental Quart.*, July, 1959, pp. 24–26, 31. Presentation of the random vibration theory and application of a nomograph to three examples.

**Damping of Flexural Waves by a Constrained Viscoelastic Layer.** E. M. Kerwin, Jr. *ASA J.*, July, 1959, pp. 952–962. 11 refs. Quantitative analysis of the damping effectiveness of a constrained layer based on the shear energy-loss mechanism. Comparisons with experimental results are made for variations in frequency, temperature, and damped-bar geometry. Experiment and theory are found to be in good agreement.

**Response of Plates to a Decaying and Convecting Random Pressure Field.** Ira Dyer. *ASA J.*, July, 1959, pp. 922–928. 16 refs. ONR-supported study of the excitation of a finite plate by a random pressure field whose correlation is decaying exponentially and convecting with constant pressure over the field. Two specific examples for varying convection speeds, illustrating their influence on the mean square plate displacement, are also included.

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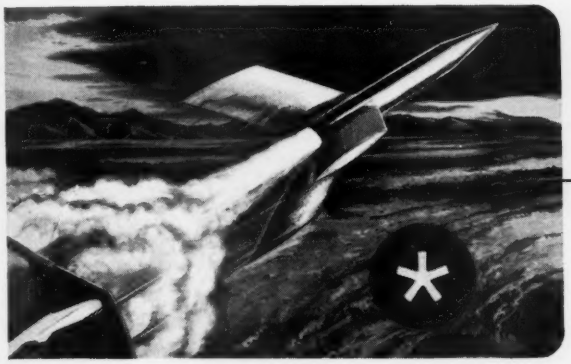

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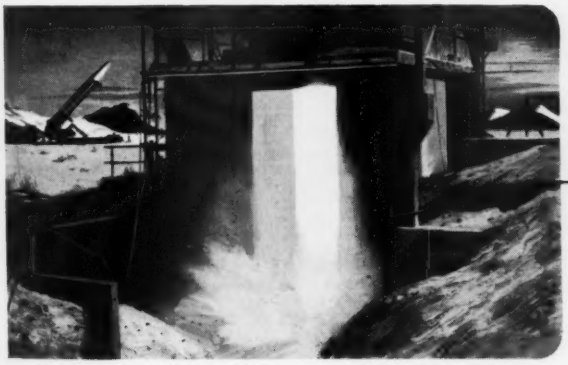

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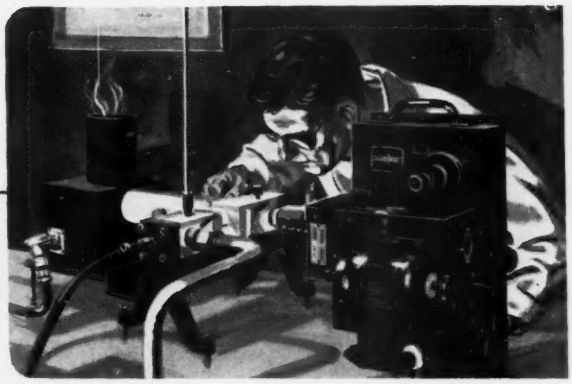

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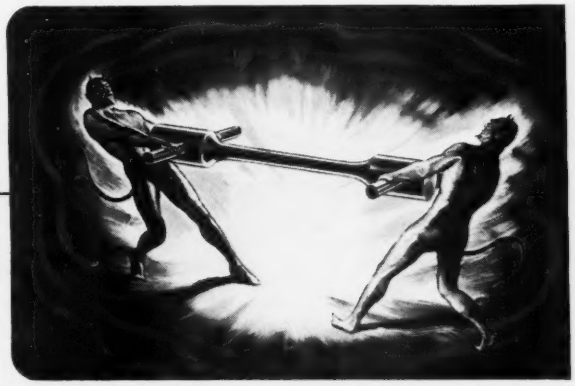

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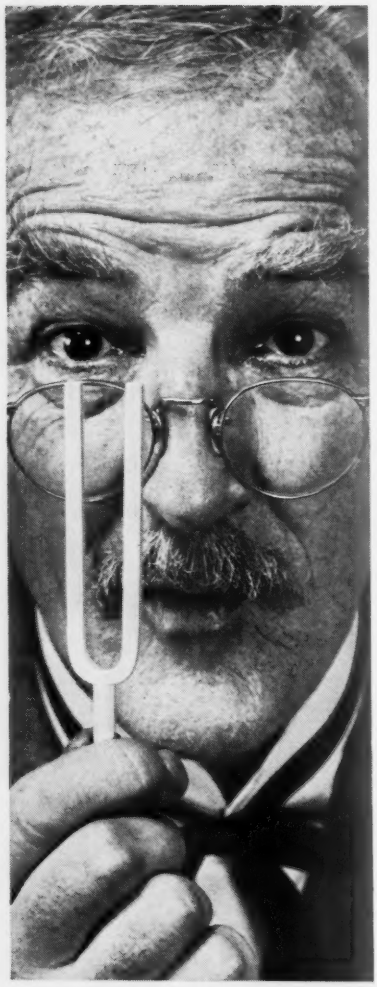

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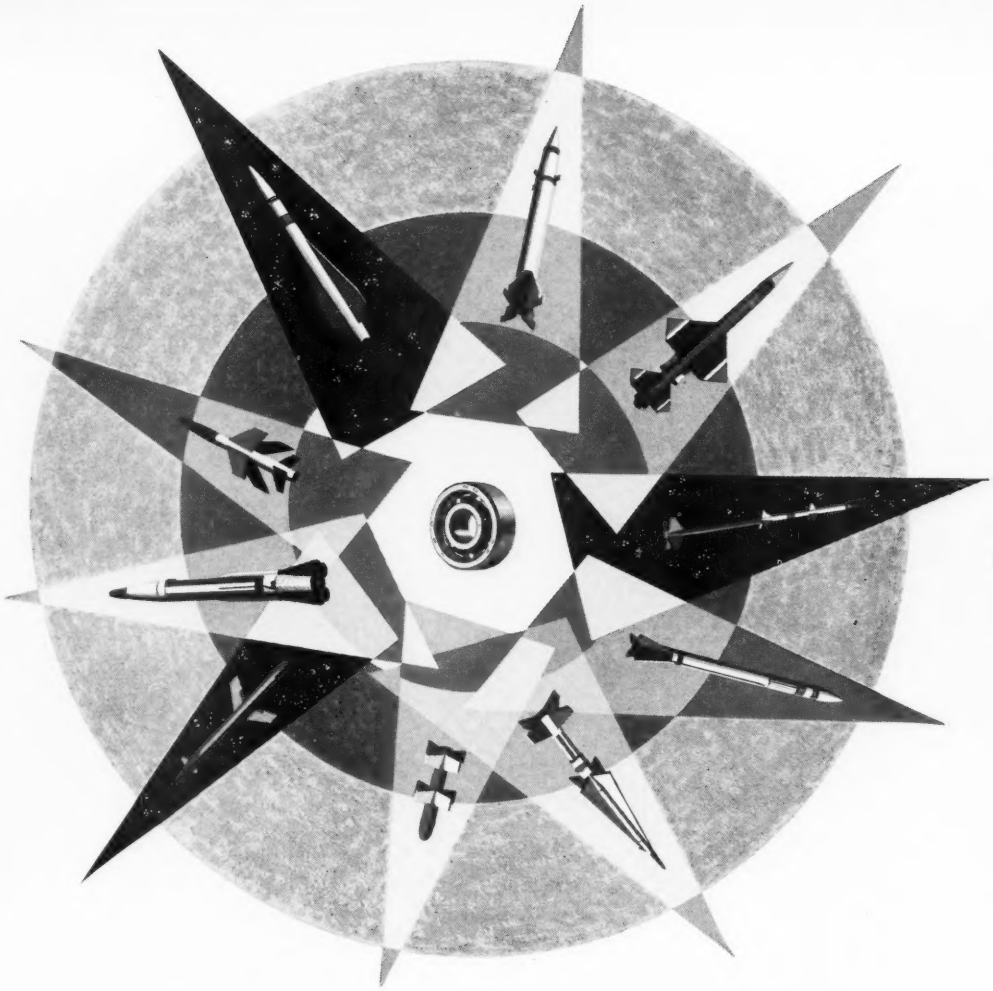

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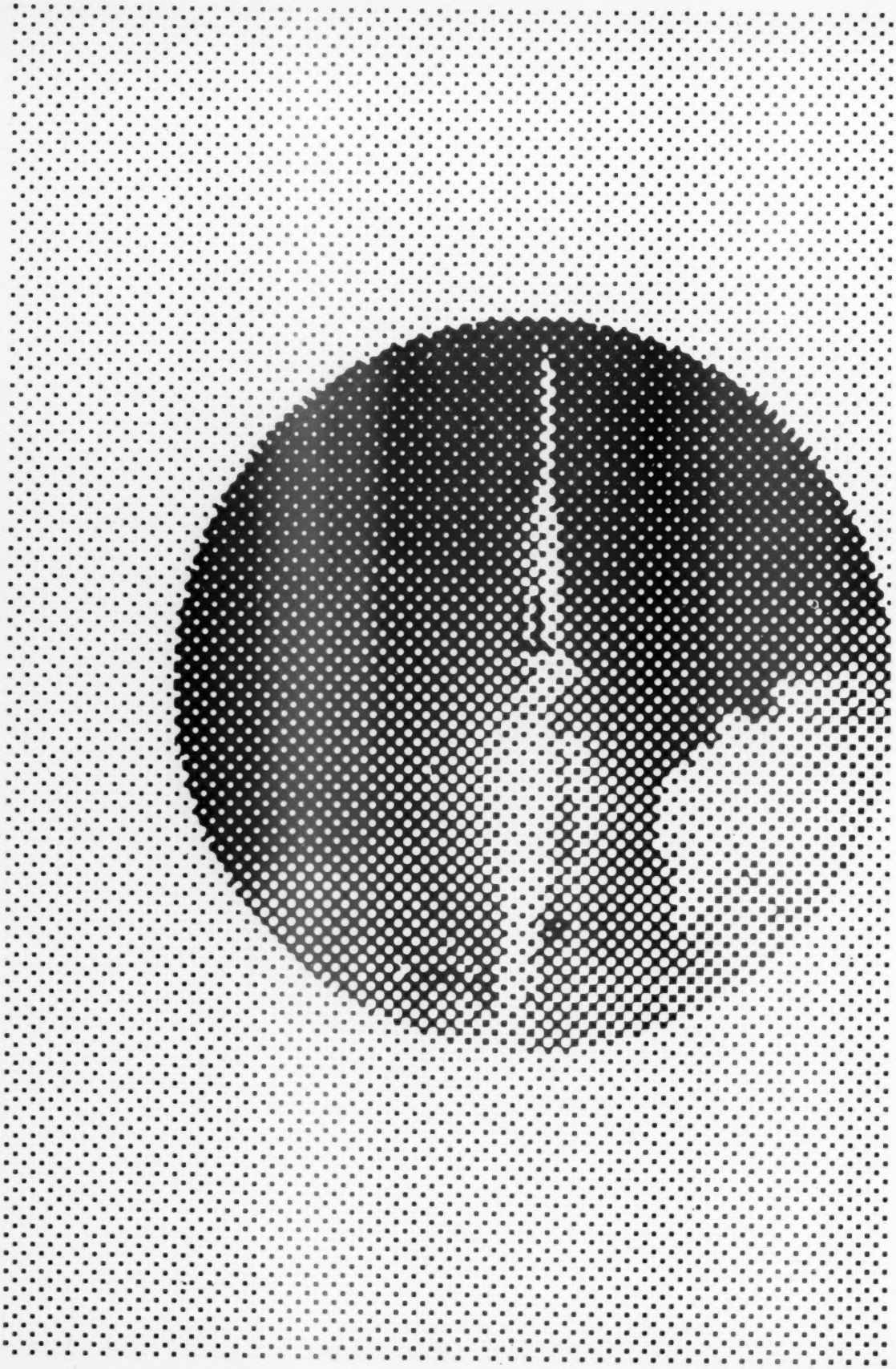



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# HOT GAS SYSTEM COMPONENTS NOW AVAILABLE FROM CHANDLER EVANS

CECO SYSTEMS CONTROLS

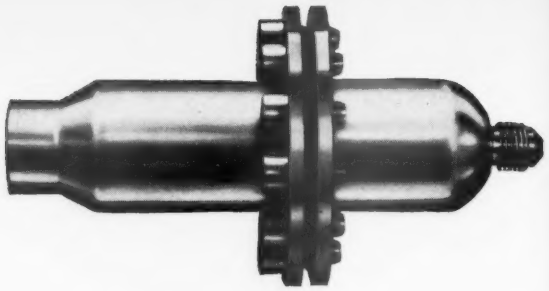
As by-products of extensive development work in the field of high-pressure pneumatics, Chandler Evans has—over the past several years—designed, developed, tested and produced a number of hot gas servo system components, some of which are presented here.

The products shown and described were developed for use with high-pressure hot gas generated from liquid or solid propellants, and are suitable to such applications as auxiliary and control power systems for guided missiles and space vehicles.

All the components shown are developed items, ready for use. However, because they have been fabricated to meet the requirements of particular applications, the specifications presented should be considered only representative. Design modifications can readily be made to adapt these devices to *your* requirements.

If you, too, are engaged in hot gas systems work and want to save considerable time and money in development, by using proven components not heretofore available, CECO will be happy to afford you its traditional cooperation.

For detailed information on these and other components, or for data on CECO's hot gas servo *systems*, contact any of the Field Engineering Offices listed at the right.

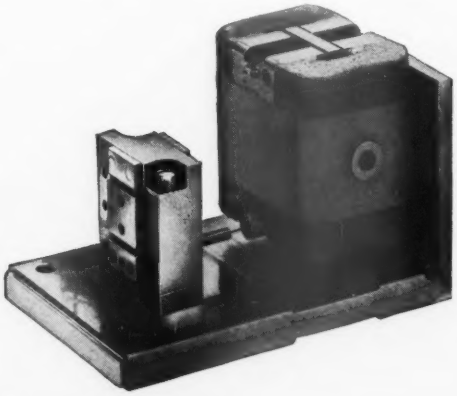


**LIGHTWEIGHT HYDRAZINE REACTION CHAMBER**

This reaction chamber, containing a suitable catalyst bed and injection nozzle, is used to generate hot gas. When hydrazine from a pressurized source is introduced, the catalyst immediately initiates a chemical reaction which continues until the fuel supply is exhausted.

**Representative specification:**

| | |
|---|---|
| Operating temperature | to 1800°F. |
| Operating pressure | to 2000 psi |
| Flow capacity | .10 lb./sec. |
| Operating time | in excess of 5 hrs. |
| Weight (including catalyst) | 1.27 lbs. |
| Size | 1.50″ O.D. x 5.00″ |



**REED-SUSPENDED, CLOSED CENTER SERVO VALVE**

Developed for use with hot gas produced by decomposition of liquid propellants, the servo valve shown here is currently available in a variety of sizes to accommodate the requirements of individual applications.

**Representative specification:**

| | |
|---|---|
| Inlet gas supply pressure | to 2000 psi |
| Inlet gas supply temperature | to 1500°F. |
| Operating temperature (ambient) | to 350°F.* |
| Valve stroke | ±.004″ |
| Flow capacity (total gas flow) | .01 lb./sec. air @ 1500°F., 2000 psi |
| Overboard leakage (valve at null position) | 10% of total flow |
| Power input (maximum) | 2 watts |
| Natural frequency | 430 cps |
| Weight | 1.00 lb. |
| Size | 1.75″ x 2.75″ x 1.75″ |

** With additional torque-motor cooling, ambients to 1200°F. can be tolerated.*

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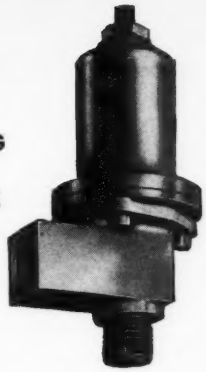
## PROPELLANT FLOW MODULATING AND PRESSURE REGULATING VALVE



The problem of operating hot gas generators at a specified constant pressure level led to the design, test and development of the liquid fuel regulating valve pictured here.

This valve may be described as a spring-loaded, spool-type throttling valve. Full open when the pressure at its outlet port (gas generator pressure) is low, it progressively closes off as the outlet pressure increases.

With minimum leakage an important objective, the valve shown meets the following specification:

| | |
|---|---|
| Flow (hydrazine) | .002 to .02 lb./sec. |
| Upstream pressure | 500 to 3000 psi |
| Regulated pressure | 500 to 2000 psi |
| Temperature | 0° to 200°F. |
| Weight | .38 lb. |
| Size | 1.75" O.D. x 3.00" |

Limited changes in regulated pressure can readily be accomplished by means of a simple adjustment screw. Broader changes in regulated pressure or in flow capacity can be accomplished through slight re-design of the spool or spring elements.

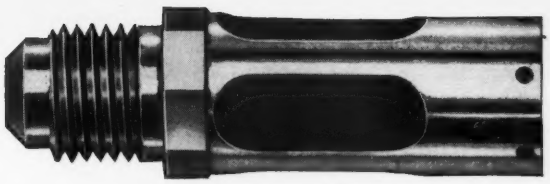
## SOLID PROPELLANT HOT GAS FILTER

Since small-orifice areas of servo valves cannot tolerate contaminants produced by combustion of solid propellants, CECO found it necessary to develop the special hot gas filter shown here. Unlike those heretofore available, this filter can easily be cleaned for re-use and has amply demonstrated its ability to withstand the temperatures and pressures encountered in hot gas systems.

It operates as follows: hot gas flows into an annulus between the filter element and housing, then diffuses through to the outer surface of the element, depositing solid particles as it goes. With gas flow at .015 lb./sec., this filter operates for several minutes, with average contamination, filtering out particles as fine as 10 microns.

**Representative specification:**

| | |
|---|---|
| Operating temperature | to 1800°F. |
| Operating pressure | to 2000 psi |
| Initial pressure drop at .015 lb./sec. | 2 psi @ 1000 psi |
| Filter housing size | 1.38 O.D." x 5.00" |
| Weight | .88 lb. |

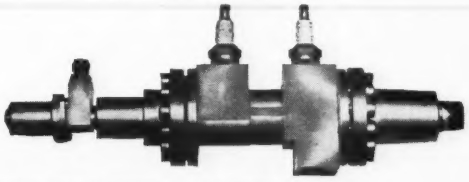


## HOT GAS PRESSURE RELIEF VALVE

Typical of component hardware developed by CECO in its work with hot gas servo actuation and reaction systems is the valve pictured here. While it can easily be modified to satisfy other requirements, specification for the valve shown is as follows:

| | |
|---|---|
| Relief pressure | 1000 psi* |
| Reseat pressure | 950 psi |
| Flow | .02 lb./sec. @ 1000 psi |
| Temperature | 1800°F. |
| Weight | .032 lb. |

* *Adjustable from 800 to 1200 psi.*



## HOT GAS REACTION CHAMBER FOR LABORATORY USE

This unit is used as a "workhorse" hydrazine reaction chamber to provide clean, hot, high-pressure gas for test purposes.

Ideal for laboratory use, its flow rates range between .001 and .1 lb. sec., and may be extended in either direction by changing nozzle and load orifice sizes. Operating temperatures are between 1200°F. and 1800°F. with pressures to 2000 psi.

The chamber is preheated by an electrical coil, a feature which facilitates repetitive starting without need for disassembly between test runs to renew the catalyst.

The above picture shows CECO's generator with the pressure regulating and flow modulating valve in position. For those who require a complete, "packaged" system for providing a continuous supply of hot gas, Chandler Evans can supply a complete laboratory model hot gas generator system including the fuel storage, pressurizing, purging and pressure regulating elements in addition to the gas generator reaction chamber described above.

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*NYU Grad. Sch. Arts & Sci. Phys. Dept. Final Rep.*, Jan. 1, 1959. 49 pp. 10 refs. USAF-supported investigation of scattering by means of two intersecting electron beams. With a 30° angle between the beams, the collisions produce higher and lower energy components in the forward cone.

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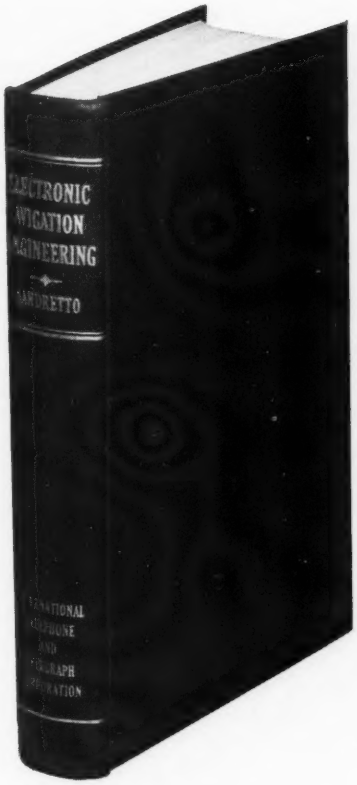


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### Flow Measuring Devices

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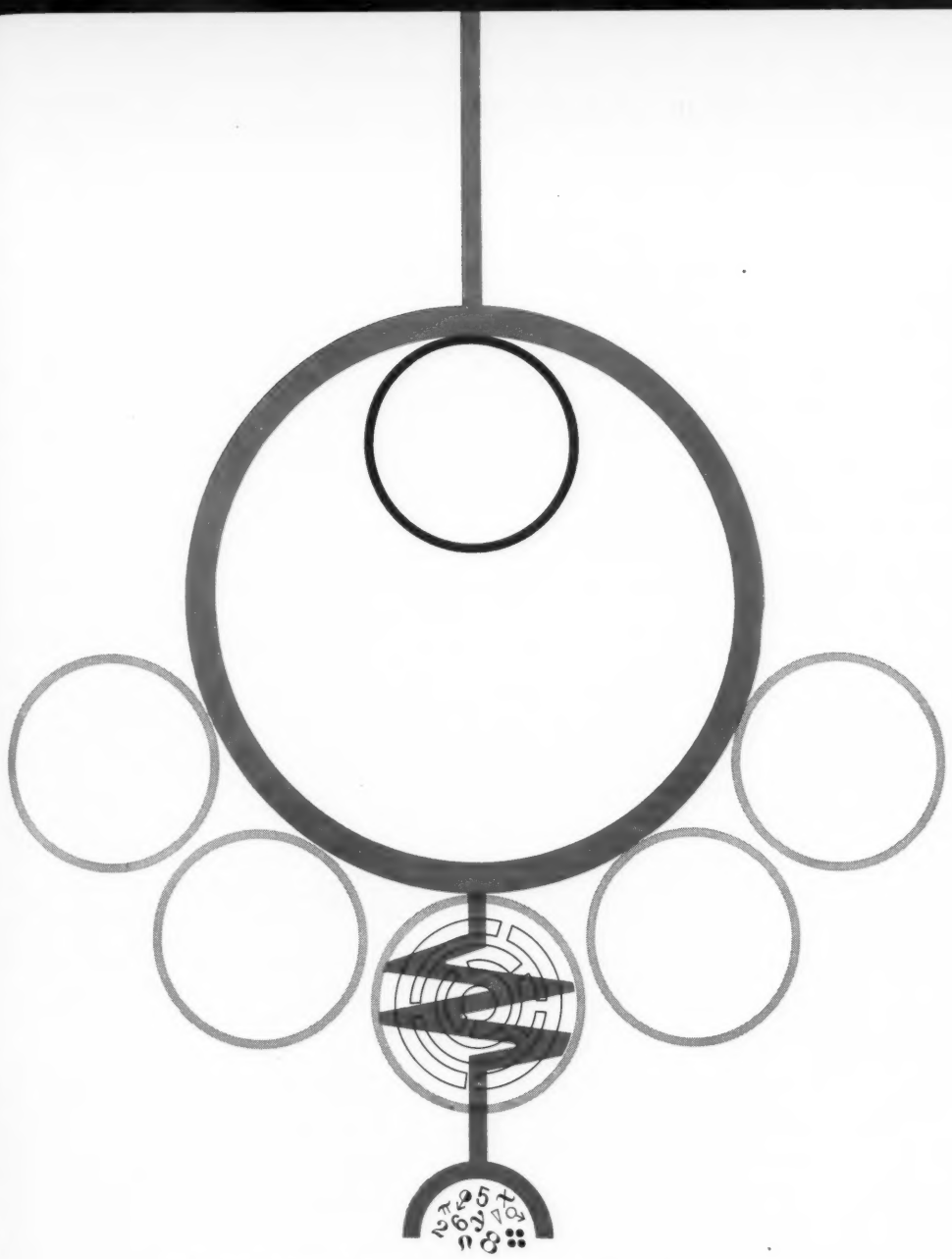

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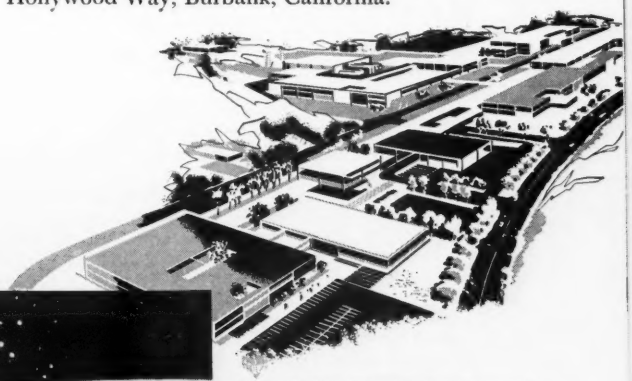

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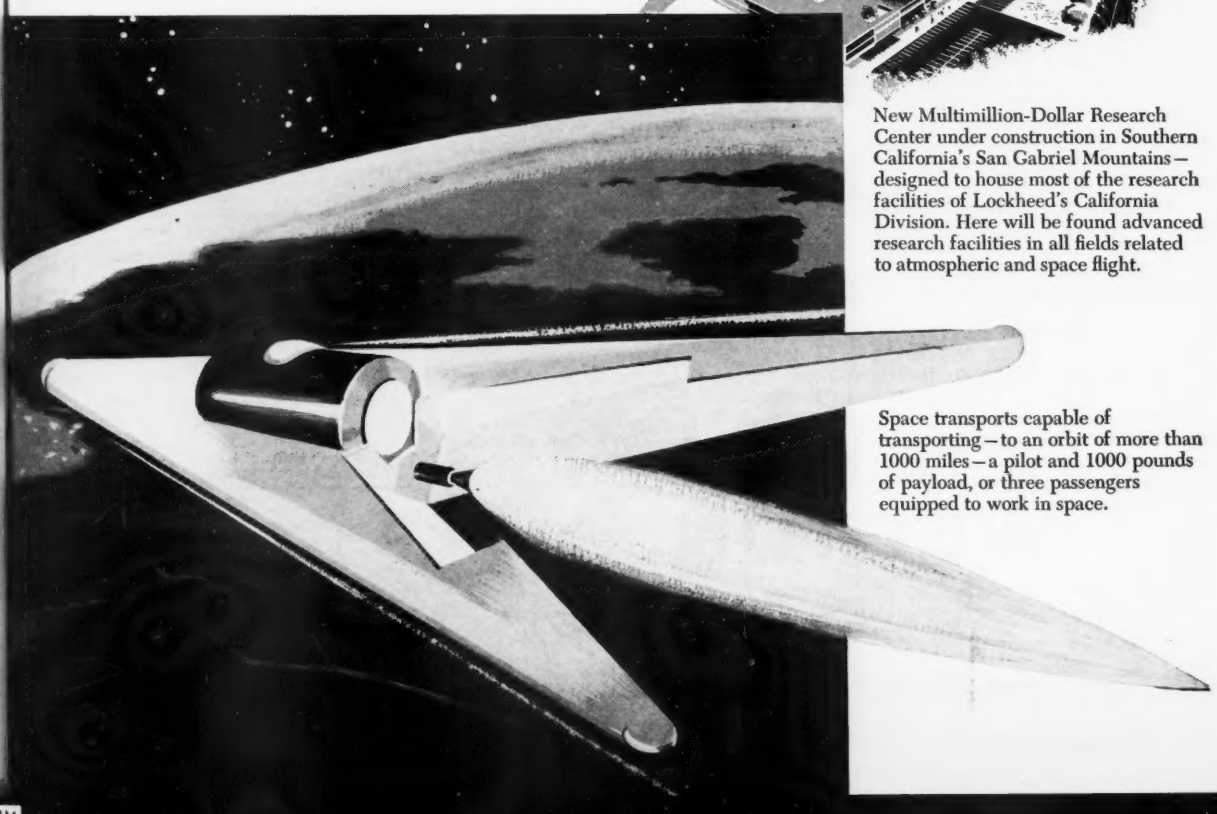

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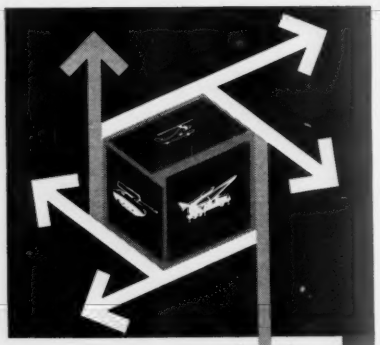

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## Navigation

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**Schirmbilddarstellungen bei Präzisionsanflug-Radaranlagen.** Gunther Paul. *ZFW*, July, 1959, pp. 181–193. In German. Discussion of several precision approach radar (PAR) display screens, such as linear or nonlinear displays, AZ-EL or Beta displays, and fixed or electronic PAR maps, with respect to their clearness of presentation and engineering requirements.

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**Augmentation of Nuclear Rocket Specific Impulse Through Mechanical-Electrical Means.** Martin Goldsmith. *ARS J.*, Aug., 1959, pp. 600, 601. Calculation of the augmentation of specific impulse possible through the use of Ackeret's cycle for some realistic designs. Values are assumed for the various parameters that enter into the problem.

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**Reduction of Ballistic Camera Plates.** Appendix I—**Definitions of Astronomical Quantities.** Appendix II—**Sidereal Time.** Appendix III—**Atmospheric Refraction.** Appendix IV—**Direction Cosines of Stars Referred to the XYZ-Axes.** Appendix V—**Roll Angle—R.** Appendix VI—**Rotation Matrix for Converting from the XYZ-Coordinate System to the Camera-Coordinate System X″Y″Z″.** Appendix VII—**Measurement of and Correction for the Obliquity of the Ways of a Two-Screw Comparator.** Ch. A. Bodwell and P. D. Jose. *USAF MDC PST TR 59-5* [*AD 154107*], Jan., 1959. 63 pp.

**Photographic Image-Density Isolation.** Frank Scott. *Photographic Sci. & Eng.*, July-Aug., 1959, pp. 181–185. Discussion of a photographic technique to study radar reflectivity, stability of radar targets, and other aspects of radar reconnaissance photographic recording.

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**Technical Report of Research Performed Between October 1, 1956 and September 30, 1958.** *Ecole Norm. Supér. Lab. Phys. Serv. Phys. Théoret. TR* (*AFOSR TN 59-224*) [*AD 211606*], 1959. 71 pp. 38 refs. Summary of work performed on nucleon and antinucleon forces.

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**Comparison of the Pair Theory and the Quasi-Particle Method for the Evaluation of the Properties of an Interacting Bose System.** J. Peretti. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-182* (*AFOSR TN 59-850*), Aug., 1959. 12 pp.

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**The Pair Distribution Function of a Bose Hard Sphere System, Calculated to the First Order of the Scattering Length.** L. Colin and J. Peretti. *U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-179* (*AFOSR TN 59-739*), July, 1959. 45 pp.

**Condensation of an Imperfect Boson Gas.** R. H. Kraichman. *Phys. Fluids*, July-Aug., 1959, pp. 463–465. AFOSR-supported discussion of the nature of the Einstein-Bose condensation in an imperfect boson gas. It is suggested that the actual Einstein-Bose condensation takes place in energy rather than momentum, but that even in terms of this variable it becomes perfectly sharp only at zero temperature.

**Determination of Surface Free Energy of Metals and Polymers.** Appendix I—**Derivation of the Equation for the Apparent Surface Tension.** Appendix II—**Wheatstone Bridge Calculations.** James Haygood, Robert Ullman, and S. Z. Lewin. *USAF WADC TR 59-147* [*AD 211923*], Apr., 1959. 78 pp.

**Effects of Atomic Electrons on p-p and n-p Scattering.** G. Breit. *Yale U. Nuclear Phys. Div. Paper* (*AFOSR TN 59-369*) [*AD 213861*], Apr., 1959. 3 pp.

**Interferometric Spectroscopy in the Far Infrared.** John Strong and G. A. Vanasse. *OSA J.*, Sept., 1959, pp. 844–850. 20 refs. USAF-supported comparison of Michelson's visibility technique for obtaining spectral distributions interferometrically in the visible region with a new far-infrared interferogram method.

**The Beta Decay of $K^{40}$.** W. H. Kelly, G. B. Beard, and R. A. Peters. (*Nuclear Phys.*, No. 11, 1959, pp. 492–498.) *Mich. State U. Phys. Dept. Paper* (*AFOSR TN 59-75*) [*AD 209917*], July 20, 1959. 7 pp. 12 refs. Reprint.

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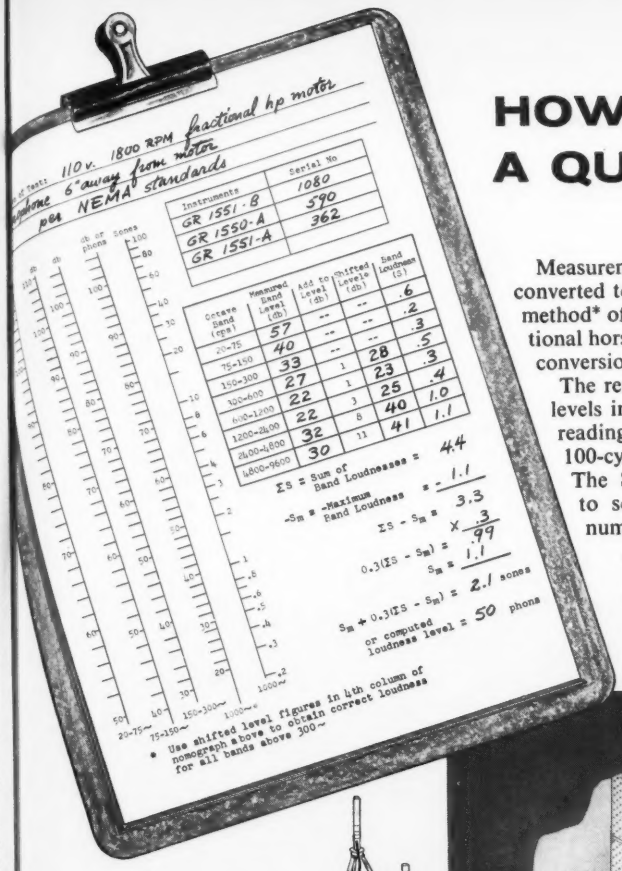
**Wide rf Level rf Unit for an NMR Spectrometer.** K. N. Kapur and J. W. McGrath. (*Rev.*

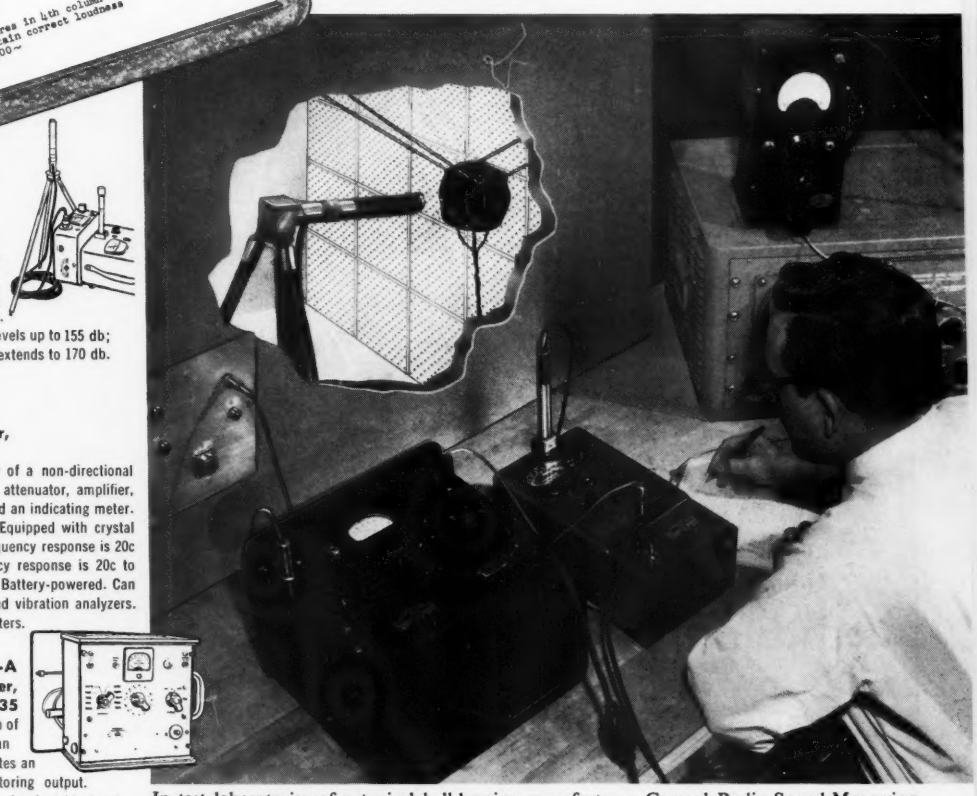
# HOW QUIET IS A QUIET MOTOR?


Tests: 110 v. 1800 RPM fractional hp motor
Mike 6" away from motor
per NEMA standards
Instruments
GR 1551-B
GR 1550-A
GR 1551-A
Serial No
1080
590
362
Octave Band (cps)
Measured Band Level (db)
Add to Level (db)
Shifted Levels (db)
Band Loudness (S)
20-75 57 -- -- .6
75-150 40 -- -- .2
150-300 33 -- -- .3
300-600 27 1 28 .3
600-1200 22 1 23 .5
1200-2400 22 3 25 .4
2400-4800 32 8 40 1.0
4800-9600 30 11 41 1.1
ΣS = Sum of Band Loudnesses = 4.4
-Sm = -Maximum Band Loudness = -1.1
ΣS - Sm = 3.3
0.3(ΣS - Sm) = X .3 .99
Sm = 1.1
Sm + 0.3(ΣS - Sm) = 2.1 sones
or computed loudness level = 50 phons
* Use shifted level figures in 4th column of nomograph above to obtain correct loudness for all bands above 300~

Measurements with the G-R 1550-A Octave-Band Noise Analyzer can be converted to an approximate subjective loudness in sones using the Stevens method* of calculation, as is illustrated on the typical data sheet for a fractional horsepower motor. The nomograph on this data sheet permits direct conversion of decibels to sones for each octave band.

The results of these calculations are more valuable than sound-pressure levels in specifying product noise, since sounds producing equal decibel readings do not always *sound* as though they are equal, i.e., an 80-db 100-cycle tone does not sound as loud as an 80-db broad-band noise. The Stevens method avoids such difficulties by converting db levels to sones, thereby permitting a means of specifying loudness in a numerical language that is more closely related to hearing.

*S. S. Stevens, "The Calculation of the Loudness of Complex Noise," Journal of the Acoustical Society, September, 1956, states that loudness in octave bands can be combined by the formula: $S_t = S_m + 0.3\,(\Sigma S - S_m)$, where $S_t$ is total loudness in sones, $S_m$ is the loudness of the loudest band, $\Sigma S$ is the sum of the loudnesses of all the bands. Also see S. S. Stevens, "The Measurement of Loudness," Journal of the Acoustical Society, September, 1955; and S. S. Stevens, "Calculating Loudness," Noise Control, September, 1957.



In test laboratories of a typical ball-bearing manufacturer, General Radio Sound-Measuring equipment is used for electric-motor noise investigations, particularly to determine effects of ball-bearing assemblies and mounting methods. Because small-motor noise is often high pitched, a condenser microphone capable of measuring the higher audible frequencies is used. The Octave-Band Noise Analyzer shown operating from the Sound-Level Meter determines the noise spectrum produced by the motor.



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**Planetary Astronomy from Satellite-Substitute Vehicles. I—A Review of Meteorological and Astrophysical Programs for Observatories Carried Effectively Into Space by Satellite-Substitute Vehicles.** John Strong. *USAF MDC TN 59-22*, July, 1959. 22 pp. 11 refs.

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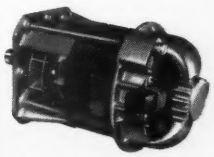

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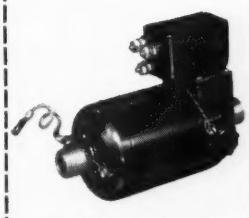

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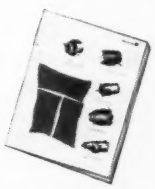

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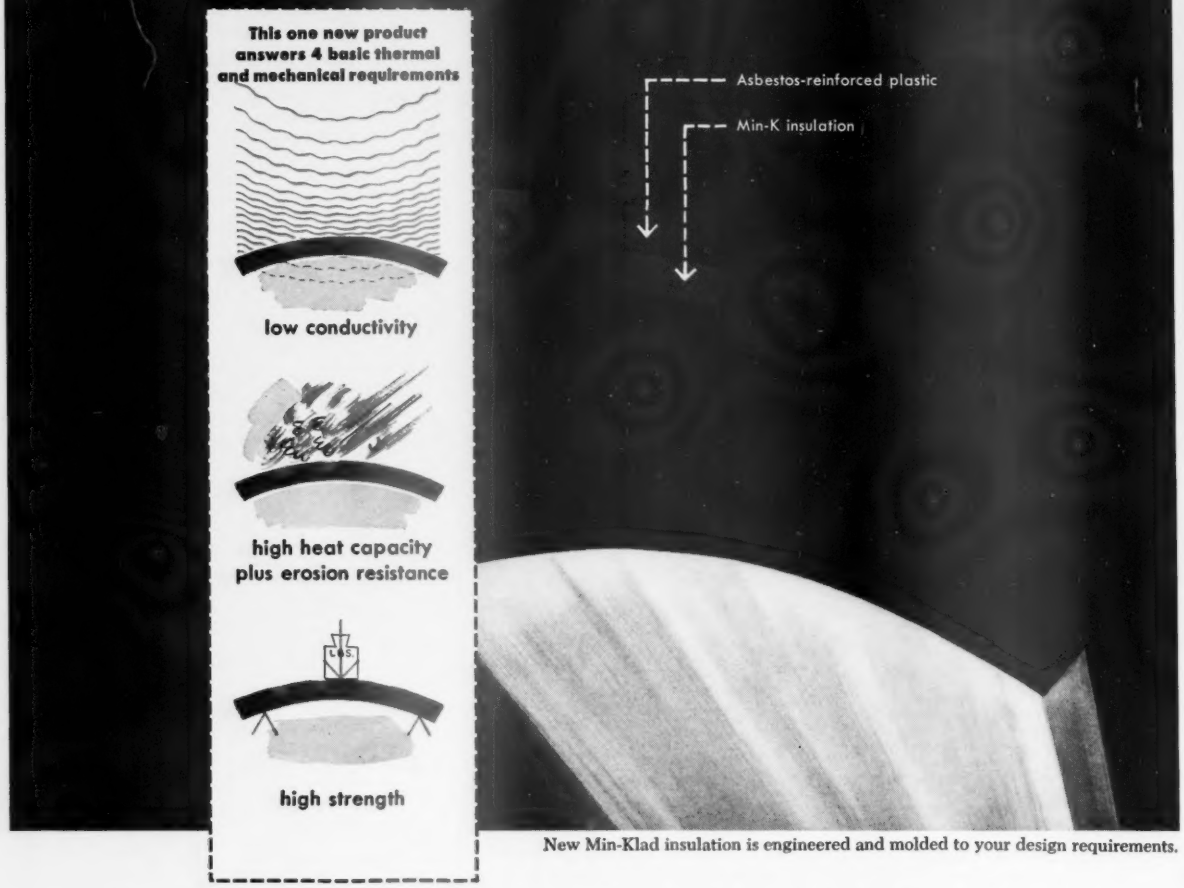
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# INTERNATIONAL AERONAUTICAL ABSTRACTS

## A Review of Worldwide Scientific and Technical Literature

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November, 1959 Volume 4, Number 11


### ACOUSTICS, SOUND, NOISE

JET-ENGINE EXHAUST NOISE FROM SLOT NOZZLES. W. D. Coles. US, NASA TN D-60, Sept., 1959. 30 pp. 20 refs. Investigation of acoustic characteristics of slot nozzles having 14:1 and 100:1 nozzle height-to-width ratios, including a jet-augmented-flap configuration with the 100:1 nozzle, using a full-scale turbojet engine installed in an airframe. Directional distribution of sound pressure level, frequency distribution, overall sound power, and power-spectrum-level values are obtained and compared with circular-nozzle noise characteristics. The noise suppressing capabilities of a slot nozzle are confined primarily to changes in the directivity and frequency of the noise. The sound power reduction indicated both in theory and experiment is slight (3 db.). Addition of the flap to the slot nozzle caused marked reductions in sound pressure level that, in combination with the reduced levels in the horizontal plane, would effectively reduce noise levels from aircraft in flight.

SOME EFFECTS OF SOUND-REDUCTION DEVICES ON A TURBULENT JET. G. M. Corcos. J. Aero/Space Sci., Nov., 1959, pp. 717-722, 730. Presentation of a solution to the problem of aerodynamic noise reduction by introducing ejectors, corrugated nozzles, and multiple nozzles that modify the turbulent mixing of a jet. Simple analytic and dimensional considerations lead to the conclusion that the noise reduction is due primarily to a decrease in turbulence levels in the mixing region. It is suggested that this is accomplished by accelerating the ambient air through a longitudinal pressure gradient before mixing it with the jet. Thus, a sheath of flowing air decreases the lateral jump in the mean axial velocity which is responsible for the turbulence level in the mixing region. An experiment at low speed with an ejector and a corrugated nozzle is described.

GROUND MEASUREMENTS OF THE SHOCK-WAVE NOISE FROM AIRPLANES IN LEVEL FLIGHT AT MACH NUMBERS TO 1.4 AND AT ALTITUDES TO 45,000 FEET. D. J. Maglieri, H. H. Hubbard, and D. L. Lansing. US, NASA TN D-48, Sept., 1959. 38 pp. 10 refs. Presentation of time histories for noise pressures near ground level during flight tests over fairly flat, partly wooded terrain. Atmospheric soundings and radar-track studies were made for correlation with measured noise data. The measured and calculated values of the pressure rise across the shock wave were generally in good agreement. There is a tendency for the theory to overestimate the pressure at locations remote from the track and to underestimate the pressures for conditions of high tailwind at altitude.

### AERODYNAMICS, FLUID MECHANICS

#### Aerothermochemistry, Dissociation, Ablation

EFFECTS OF CHEMICAL DISSOCIATION AND MOLECULAR VIBRATIONS ON STEADY ONE-DIMENSIONAL FLOW. Appendix A - DERIVATION OF ENTROPY EQUATION. Appendix B - CHARACTERISTIC CONSTANTS FOR VARIOUS GASES. Appendix C - DISCUSSION OF THE EQUILIBRIUM CONSTANT. S. P. Heims. US, NASA TN D-87, Aug., 1959. 66 pp. 37 refs. Derivation of equations from which the one-dimensional flow of gases simultaneously subject to dissociation and vibration can be computed. The cases considered include both frozen and equilibrium flows and flows where either dissociation or vibration is frozen while the other is in equilibrium. These flows are isentropic if no shocks occur in the region considered and if viscosity and heat conduction are negligible. It is found that for flow of the gas in chemical equilibrium the temperature and the degree of dissociation are convenient independent variables to use. They are related through the entropy, a constant along the flow. Flows in which the chemical reaction and vibrations are not in equilibrium are also studied. In these flows the entropy increases along the stream tubes, even when viscosity, heat conduction, and shock waves are absent.

NONEQUILIBRIUM FLOW IN GAS DYNAMICS. T. Y. Li. Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5901 (AFOSR TN 59-389) [AD 213893], May, 1959. 68 pp. 35 refs. Investigation covering the general concepts which include (a) the fundamental equations and boundary conditions in problems of steady adiabatic inviscid flow of a reacting mixture of perfect gases and (b) a general study of the chemical relaxation in a gaseous system. The steady one-dimensional nozzle flow with nonequilibrium chemical reactions is also studied. An important nondimensional parameter is used to classify the nozzle flow into (a) equilibrium flow, (b) nonequilibrium flow, and (c) the frozen flow. Significant departure from equilibrium flow in a hypersonic shock tunnel nozzle would lead to frozen flow further downstream. A numerical method is presented, whereby the inviscid adiabatic flow of a reacting mixture of perfect gases past a blunt body may be calculated. Numerical examples show that significant changes in the flow conditions of the shock layer region can be attributed to the chemical nonequilibrium effects.

ATOMIC RECOMBINATION IN A HYPERSONIC WIND-TUNNEL NOZZLE. K. N. C. Bray. J. Fluid Mech., July, 1959, pp. 1-32. 21 refs. Analysis considering the flow of an ideal dissociating gas through a nearly conical nozzle. The equations of one-dimensional motion are solved numerically assuming a simple rate equation together with a number of different values for the rate constant. These calculations suggest that deviations from chemical equilibrium will occur in the nozzle if the rate constant lies within a very wide range of values and that, once such a deviation has begun, the gas will very rapidly "freeze." The dissociation fraction will then remain almost constant if the flow is expanded further, or even if it passes through a constant area section. An approximate method of solution, making use of this property of sudden "freezing" of the flow, has been developed and applied to the problem of estimating the deviations from equilibrium under a wide range of conditions. The shape of an optimum nozzle is derived in order to minimize this departure from equilibrium.

AN APPROXIMATE ANALYSIS OF UNSTEADY VAPORIZATION NEAR THE STAGNATION POINT OF BLUNT BODIES. Appendix A - STEADY-STATE SOLUTION. Appendix B - EXACT PRE-ABLATION HEATING SOLUTIONS. Leonard Roberts. US, NASA TN D-41, Sept., 1959. 31 pp. Derivation of two simultaneous nonlinear equations that can be solved to give the unsteady mass loss and the unsteady accumulation of heat by the remaining solid. In the analysis, the combined effects of boundary-layer shielding and heat conduction to the interior are represented, and the approximation involved is justified by comparing the results with known exact calculations. It is shown that the steady value of the effective heat capacity of the material can be determined even when the heating period during the experiment may not be sufficient to establish the steady state.

RECENT ADVANCES IN ABLATION. M. C. Adams. ARS J., Sept., 1959, pp. 625-632. 39 refs. Presentation of the parameters and physical properties which are important for ablating materials. Various ablation theories are reviewed and compared with specific materials where possible. The theories of melting ablation are studied, but it is concluded that materials which flow without evaporation are not of practical interest because the heat absorbing capability of such materials represents only a minor improvement over the heat sink. Subliming ablation contributes an added absorption energy over and above a material's heat capacity plus energy of evaporation. Combined melting and sublimation are examined for a glass-plastic composite and for quartz under stagnation point and turbulent heating conditions. Two applications are briefly considered for satellite re-entry and rocket nozzles.

AERODYNAMIC HEATING OF IRON METEORITES DURING ENTRY INTO THE ATMOSPHERE. R. E. Maringer and G. K. Manning. USAF WADC TR 59-164, Apr., 1959. 106 pp. 15 refs. Study of iron meteorites containing surface zones of structurally altered material which results from the heat generated during their flight through the atmosphere. By comparing the structures and hardnesses in these zones with those of artificially heated meteoritic iron specimens, thermal gradients as they exist during flight are reconstructed. Based on the data thus derived, the rates of heat flow through the meteorite surface and corresponding rates of ablation occurring during high-velocity flight are determined. A discussion of various aspects of the structure and composition of meteoritic iron, taking into account the origin and thermal history of the material, is also included.

## Aerothermodynamics

LAMINAR SKIN-FRICTION AND HEAT-TRANSFER PARAMETERS FOR A FLAT PLATE AT HYPERSONIC SPEEDS IN TERMS OF FREE-STREAM FLOW PROPERTIES. Appendix A - APPLICATION TO CONICAL SHAPES. Appendix B - THE REFERENCE ENTHALPY. Appendix C - EVALUATION OF $\rho^*\mu^*$. Appendix D - DERIVATION OF THE HEAT-TRANSFER COEFFICIENT. Appendix E - THE ADIABATIC-WALL ENTHALPY PARAMETER. Appendix F - CALCULATION PROCEDURE. J. F. Schmidt. US, NASA TN D-8, Sept., 1959. 57 pp. 24 refs. Calculation of data for a flat plate at angles of attack from $0^\circ$ to $50^\circ$ with equilibrium dissociation of air behind the shock wave and within the laminar boundary layer. These parameters are tabulated for wall temperatures between 1,000° and 3,000°R. with free-stream velocities of 10,000 to 28,000 ft./sec. over an altitude range of 50,000 to 300,000 ft.

O RASCHETE PROGREVANIIA OBOLOCHEK PRI BOL'SHIKH SKOROSTIAKH. I. N. Sokolova. AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom., May-June, 1959, pp. 90-94. In Russian. Derivation of an approximate solution for the heating



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problem of shells stabilized in a flow of gas with variable velocity, pressure, and density. The internal surface of the shell is assumed to be heat-insulated, and the heat flows along this surface are assumed to be negligible in comparison to transverse flows. The approach used to determine the temperature for the initial stage of motion is illustrated, and the accuracy of the approximate solution is evaluated.

HEAT CONDUCTION IN A CIRCULAR CYLINDER ROTATING WITH ITS AXIS NORMAL TO THE DIRECTION OF FLIGHT. Anthony Demetriades. ARS J., Sept., 1959, pp. 653-655. Study of the time-temperature history of an infinite solid cylinder when heat is transferred to it in a manner resembling heat transfer in high-speed flight, and when the cylinder is simultaneously rotating about its axis. The heat conduction equation is solved for boundary conditions peculiar to such heat transfer, and it is shown that the pertinent parameter in the solution is the ratio of the thermal wave length to the cylinder radius. For small values of this parameter (corresponding to angular speeds above a few radians per sec.) it is found that the cylinder maximum surface temperatures are reduced by a considerable amount by virtue of the rotation of the cylinder about its axis.

SOME HEAT TRANSFER PROBLEMS IN HYPERSONIC FLOW. Antonio Ferri. (Durand Centennial Conf. Aero. & Astron., Stanford, Aug. 5-8, 1959.) Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 473 (USAF WADC TN 59-308), July, 1959. 51 pp. 13 refs. Study of curved shock waves associated with blunt bodies at hypersonic velocity which produce large entropy gradients and, therefore, large shear flows interacting with the boundary layer. The effects of this shear flow are discussed for axially symmetric and two-dimensional flow fields, and for low and high Reynolds Numbers of flight. Approximate methods of heat transfer analysis are presented for the case of laminar boundary layer in the presence of a shear flow with a cold wall and in the case of zero pressure gradient. Results of an experimental investigation on the effects of interaction between external flow and laminar turbulent heat transfer and/or the effect of shear flow on transition are also presented.

SHOCK-TUBE HEAT-TRANSFER MEASUREMENTS ON INNER SURFACE OF A CYLINDER (SIMULATING A FLAT PLATE) FOR STAGNATION-TEMPERATURE RANGE 4,100° TO 8,300° R. J. J. Jones. US, NASA TN D-54, Sept., 1959. 18 pp. 10 refs. Investigation for a Reynolds Number range of $2 \times 10^5$ to $2 \times 10^7$ and a Mach Number range of 1.8 to 2.4. The turbulent results could be correlated with a curve similar in form to the classical incompressible relation, except that the heat-transfer parameter was based on enthalpy rather than temperature. The stagnation temperature range corresponds to that encountered in flight at 100,000 ft. for the Mach Number range of 7 to 14.

DATA FOR RECOVERY COEFFICIENTS IN STAGNATION REGIONS FOR M = 1.7. M. G. Morozov. Sov. Phys. - Tech. Phys., Mar., 1959, pp. 265-269. Translation. Investigation carried out on flat and conical models showing the possibility of a suitable organization of the streamline to create a surface region in which the recovery temperature will be less than the recovery temperature on a plane surface under similar conditions.

HYPERSONIC BOUNDARY LAYERS WITH SPECIAL REFERENCE TO HEAT TRANSFER. L. F. Crabtree. (RAeS Meeting, London, Dec. 15, 1958.) RAeS J., Sept., 1959, pp. 513-516; Discussion, pp. 529, 530. 14 refs. Discussion of the heat transfer to slender shapes suitable for application to sustained flight at hypervelocities. Also covered are blunt bodies, ideal flat plates, separated flows, transpiration cooling, and transition.

DIE STABILITÄT EINER HEISSEN LAMINAREN GRENZSCHICHT BEI ZUFÜHRUNG EINES KÜHLMITTELS. J. F. Gross. Raketentech. & Raumfahrtforsch., July-Sept., 1959, pp. 76-80. In German. Investigation of the stability of a laminar compressible boundary layer with addition of a diffusing coolant. The two-component boundary-layer equations are solved for the incompressible and the compressible cases. The reductions of heat-transfer and friction coefficients are presented, and it is shown that substances producing higher cooling effects reduce the stability of the boundary layer. Various methods of injection, as well as the selection of the medium, are discussed.

## Boundary Layer

EVOLUTION OF AMPLIFIED WAVES LEADING TO TRANSITION IN A BOUNDARY LAYER WITH ZERO PRESSURE GRADIENT. P. S. Klebanoff and K. D. Tidstrom. US, NASA TN D-195, Sept., 1959. 67 pp. 22 refs. Investigation of the instability of a laminar boundary layer leading to transition. Waves are introduced into the boundary layer of a flat plate using the vibrating ribbon technique, and their development and subsequent breakdown are studied using the hot-wire anemometer as the principal measuring device. The motions leading to transition are strongly three-dimensional, and the nature of this three-dimensionality is investigated. The effect of the wave on the mean flow and its behavior in relation to the Tollmien-Schlichting theory are also studied. It is demonstrated that, associated with the wave growth, there is present an energy-concentrating mechanism involving the transfer of wave energy from one spanwise position to another, resulting in streetlike concentrations of wave energy. It is also shown that the initial breakdown of laminar flow is of small extent and may be described as pointlike. Breakdown of the laminar flow occurs in the outer region of the layer, and intermittent separation is not involved in the transition process.

CONNAISSANCES ACTUELLES SUR LA TRANSITION AUX GRANDES VITESSES. R. Michel. La Recherche Aéronautique, July-Aug., 1959, pp.

29-36. 16 refs. In French. Analytical survey of previously obtained results on the boundary-layer transition at high speeds. The importance of the problem in subsonic and supersonic research is stressed, including such aspects as wall friction, boundary-layer interaction, and shock waves. The study comprises the preliminary definition of the transition point; evaluation of results obtained for the incompressible fluid; and the supersonic transition, covering separately the effect of such main factors as Mach Number, pressure gradient, heat flux, leading edge, and surface roughness.

TWO TECHNIQUES FOR DETECTING BOUNDARY-LAYER TRANSITION IN FLIGHT AT SUPERSONIC SPEEDS AND AT ALTITUDES ABOVE 20,000 FEET. Appendix - ERROR ANALYSIS OF RESISTANCE THERMOMETERS. J. G. McTique, J. D. Overton, and Gilbert Petty, Jr. US, NASA TN D-18, Aug., 1959. 30 pp. Presentation of two methods for detecting and recording transition on full scale aircraft in flight up to a Mach Number of two and an altitude of 55,000 ft. In one method, several resistance thermometers are attached to the wing of a supersonic aircraft. These thermometers are electrically connected to internal-recording circuitry to record a chordwise picture of the boundary-layer conditions on the surface of the wing. The other method involves the use of sublimable chemicals to obtain a visual indication of the laminar area. Cameras are utilized to record the sublimation process during flight.

FLIGHT RESEARCH INVESTIGATION OF LAMINAR SEPARATION OF A HIGH LIFT BOUNDARY LAYER CONTROL AIRPLANE. Dezso Gyorgyfalvy. Miss. State U. Aerophys. Dept. Res. Rep. 25, June 26, 1959. 69 pp. Army-Navy-supported study of a technique for calculating and measuring laminar separation in connection with a flight research investigation of the droop nose as an aid in delaying the leading edge stall. The calculation of laminar separation by means of the Holstein-Thwaites method is shown to be unsatisfactory; but the simple relation $U_{sep}/U_{max} = 0.94$ is found to be a good approximation. The droop nose seems to be advantageous, but the attainable gain in maximum lift is not more than about 20%.

## Control Surfaces

ON THE AILERON BUZZ IN THE TRANSONIC FLOW. Haruo Saito. U. Tokyo Aero. Res. Inst. Rep. 346, July, 1959. 39 pp. 12 refs. Analytical and experimental investigation of the phenomenon of aileron buzz. It is shown experimentally that the flow pattern near the region of the shock-boundary layer interaction takes a certain finite delay time in adapting itself to a mean steady flow pattern. This lag time is dependent mainly on the thickness of the separated boundary layer induced by the shock wave, and is shown to be the main cause of aileron buzz. A nonlinear differential equation governing the character of the aileron oscillation is proposed, which has a hinge moment term proportional to the angular velocity of the aileron cubed. Finally, methods to prevent aileron buzz are described. These include decreasing the delay time through boundary-layer suction or by increasing the frequency through the reduction in the weight of the aileron and the attachment of a spring.

## Flow of Fluids

SOLUTION OF BOUNDARY PROBLEMS IN TWO-DIMENSIONAL POTENTIAL MOTION OF INCOMPRESSIBLE PERFECT FLUID. Bolesław Szczeniowski. Arch. Budowy Maszyn, No. 2, pp. 207-257. Presentation of a new method of solution for the following boundary value problems: (a) flow around a profile of mathematically prescribed shape, placed in a uniform current; (b) determination of the form of a closed profile on which components u and v of the velocity are mathematically prescribed; (c) flow in acceleration and deceleration channels (nozzles and diffusers) having arbitrarily prescribed channel walls, with or without change in flow direction; (d) determination of the form of a channel wall on which velocity components u and v are prescribed; (e) circulation around a prescribed profile; (f) flow around a prescribed double profile.

A NEW SIMPLIFIED FORM OF NAVIER-STOKES EQUATIONS FOR CURVILINEAR FLOWS. M. C. Mathur. Miss. State U. Aerophys. Dept. Res. Rep. 24, May 30, 1959. 67 pp. 15 refs. Army-Navy-supported study of flow around elliptical inlets having leading edges of small radii of curvature. By measuring the order of magnitude of terms in the Navier-Stokes boundary-layer equations for curvilinear flows, it is found that the second Navier-Stokes equation, as simplified by Tollmien, is not valid in the region of separation on the leading edge. Two additional terms are found which should be included in the second Navier-Stokes equation for cuvilinear flows. The equations are then simplified to a new form.

ON THE THEORY OF PLANE GAS FLOWS. I. M. Iur'ev. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 201-208.) PMM - Appl. Math. & Mech., No. 1, 1959, pp. 287-299. 14 refs. Translation. Presentation of a method in which systems of equations of a type containing arbitrary constants in their coefficients can be obtained. Starting from a certain tractable solution to a system of equations of the Chaplygin-type for the plane motion of a gas, it is possible by selecting the constants to obtain good approximations to the equations of adiabatic gas flow over a wide range of velocity variation. After the application of each Legendre transformation and the generalization of the functions which generate the coefficients of the system of equations, the inverse transformation with these generalized functions is applied. Such important properties of the initial flow as continuity of the subsonic flow in the supersonic domain and uniformity of the flow at infinity are preserved. The method is applied to gas flows with transition through sonic velocity, taking the Tricomi equation as the initial equation.

ON THE SIMILARITY OF HYPERSONIC VISCOUS FLOWS AROUND SLENDER BODIES. V. V.



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Luniev. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 193-197.) PMM - Appl. Math. & Mech., No.1, 1959, pp. 273-280. Translation. Analysis considering the equations of the laminar boundary layer on sharp flat and axisymmetric bodies. For the flat plate, similar equations have been studied by Shen and Lees. Criteria for the extent of the influence of the boundary layer on the outer inviscid flow are established for $M \gg 1$. For thin bodies, conditions for the similarity of the flows are determined.

AN EXPERIMENTAL INVESTIGATION OF THE INTERFERENCE BETWEEN BODIES OF REVOLUTION AT TRANSONIC SPEEDS WITH SPECIAL REFERENCE TO THE SONIC AND SUPERSONIC AREA RULES. Georg Drougge. Appendix - APPLICATION OF THE TRANSONIC PRINCIPLE OF EQUIVALENCE TO A PAIR OF BODIES OF REVOLUTION. S. B. Berndt and L. O. A. Hilding. Sweden, Flygtekniska Försöksanstalten, FFA Medd. 83, 1959. 37 pp. 14 refs. Experimental investigation of the transonic similarity rules and the sonic and supersonic area rules by means of interference tests on a pair of slender bodies of revolution at transonic and low supersonic speeds. A rather special kind of application of the area rules provides good agreement with theory, and some information on the applicability of the area rules is gained. The area rules are used to find low drag configurations with two or three adjacent bodies of revolution. The results show large drag reductions and good agreement with some supersonic area rule computations.

HIGH SUBSONIC FLOW PAST A WEDGE IN A TWO-DIMENSIONAL WIND TUNNEL AT ITS CHOKED STATE. Shigeki Morioka. Phys. Soc. Japan J., Aug., 1959, pp. 1,098-1,101. Investigation of two-dimensional high subsonic flow at the choked state past a symmetrical double-wedge profile placed midway between two parallel walls. The subsonic flow field over the front half of the profile is given by the relaxation solution for a Tricomi boundary value problem in the hodograph plane. The supersonic flow over the rear half is calculated by the method of characteristics. The results for the pressure distribution and the choking Mach Number are found to agree well with Marschner's analytical results over a fairly wide range of the transonic parameter.

SOME TESTS ON THE FORMATION OF CONICAL FLOWS DUE TO SEPARATION. H. A. Gorges. Australia, WRE TN HSA 50, Apr., 1959. 14 pp. Investigation of the flow separation on the surface of a cone-tipped probe in the presence of a blunt afterbody leading to the existence of two stable conical flow configurations. The conditions governing transition from one flow pattern to the other on a particular model were investigated in a 6-in. x 6-in. intermittent supersonic wind tunnel. The critical length at which transition occurs and the free-stream Reynolds Number affecting the character of the transition are determined. It is found that transition occurs for detached shocks at the tip as well as for the attached ones.

EXPERIMENTAL PRESSURE DISTRIBUTIONS OVER BLUNT TWO- AND THREE-DIMENSIONAL BODIES HAVING SIMILAR CROSS SECTIONS AT A MACH NUMBER OF 4.95. J. D. Julius. US, NASA TN D-157, Sept., 1959. 13 pp. 10 refs. Presentation of measurements about two- and three-dimensional bodies having flat, hemispherical, and oval leading edges. For the hemispherical models, the pressures decreased faster with distance from the stagnation point over the three-dimensional model than over the two-dimensional model. For the flat-leading-edge models, the reverse was true. The pressures over the oval-leading-edge models decreased at approximately the same rate. Modified Newtonian theory, without centrifugal-force corrections, predicted pressures on the hemispherical three-dimensional model very well.

CALCULATION OF THE INFLUENCE OF CENTRIFUGAL FORCES ON SURFACE PRESSURE FOR A BODY OF ARBITRARY SHAPE IN HYPERSONIC FLOW. G. I. Maikapar. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 64-69.) PMM - Appl. Math. & Mech., No. 1, 1959, pp. 83-91. Translation. Presentation of a method for calculating surface pressure on a body of arbitrary shape for the limiting case of a layer of vanishing thickness behind the bow shock. The streamlines in the layer behind the shock are determined as unaccelerated particle paths at the body surface expressed as a function of the initial velocities. The streamline distribution through the layer is then found from the equation of continuity, and the pressure at the body surface is computed when the streamlines are known.

ECOULEMENTS HYPERSONIQUES TRIDIMENSIONNELS DANS UNE COUCHE DE CHOC D'EPAISSEUR EVANESCENTE. J.-P. Guiraud. La Recherche Aéronautique, July-Aug., 1959, pp. 11-28. 20 refs. In French. Development of the theory on a three-dimensional Newtonian flow around an arbitrarily shaped obstacle. Includes evaluation of the hypothesis stating that the flow is nonturbulent up to a shock layer of zero thickness and that the gas does not possess volume forces. The structure of the flow in the shock layer is described, and the pressure at any point of the shock layer is given by a simple formula involving only geometric elements connected with the surface of the obstacle, such as the curvature tensor and the inclination of the tangent plane in the direction of the incident flow. Three applications are described in detail. These include: total pressure and stress over the lower surface of an airfoil; pressure over a cone of revolution at low incidence and with initial pressure gradient at the apex; and the total stress for a cone of revolution at incidence.

MEASURED AND THEORETICAL FLOW FIELDS BEHIND A RECTANGULAR AND A TRIANGULAR WING UP TO HIGH ANGLES OF ATTACK AT A MACH NUMBER OF 2.46. F. J. Centolanzi. US, NASA TN D-92, Sept., 1959. 77 pp. 10 refs. Investigation of the flow fields behind two low aspect ratio wings for angles of attack of

0°, 6°, 20°, and 30°. The downwash, sidewash, Mach Number, and dynamic pressure in the wake of both wings are compared with the predictions of various theoretical methods. The results show that for angles of attack up to 20° these flow quantities can be calculated with sufficient accuracy for most engineering purposes. The measured downwash, dynamic pressure, and Mach Number in the wake of the rectangular wing are used to estimate the effectiveness of a hypothetical tail placed at various heights above and below the chord plane of the wing.

AN APPROXIMATE METHOD FOR CALCULATING SURFACE PRESSURES ON CURVED PROFILE BLUNT PLATES IN HYPERSONIC FLOW. Appendix - THE PLANE BLAST WAVE. M. O. Creager. US, NASA TN D-71, Sept., 1959. 27 pp. Investigation of the effects of profile curvature on the flow over blunt plates. A method of calculating surface pressures which utilizes a combination of viscous and inviscid hypersonic parameters is developed, and a comparison is made to an experiment conducted in air and helium over a range of Mach Numbers from 4 to 13.3 for elliptic and circular leading edges. The comparison of theory and experiment indicates that the prediction scheme developed may be used to estimate the complete pressure distribution over blunt plates, including regions close to the stagnation point.

GENERAL CHARACTERISTICS OF HYPERSONIC FLOW FIELDS. R. N. Cox. (RAeS Meeting, London, Dec. 15, 1958.) RAeS J., Sept., 1959, pp. 503-508; Discussion, p. 529. 27 refs. Developmental survey of hypersonic research including a definition of the hypersonic flow concept. The Newtonian theory is evaluated, and flows over slender and blunt bodies are covered along with the blast wave analogy, the shock - boundary layer interaction, and the case of the blunt slender body.

SOME SPECIAL ASPECTS OF HYPERSONIC FLOW FIELDS. K. W. Mangler. RAeS J., Sept., 1959, pp. 508-512. 13 refs. Discussion covering (a) the flow field between the bow wave and the blunt body and (b) the boundary layer behind the shoulder of the body for the simple case of a body of axial symmetry at zero incidence. The flow field past a lifting body is also included in the survey.

K STATISTICHESKOI DINAMIKE NESZHIMAEMOI TURBULENTNOI ZHIDKOSTI. B. I. Davydov. AN SSSR Dokl., Aug. 1, 1959, pp. 768-771. In Russian. Investigation covering the case of developed turbulence occurring at high values of the Reynolds Number, taking into account the flow bounded by solid walls and its singular boundary layer with logarithmic mean-velocity profile. The calculation indicates that, with time, the distribution of fluctuating velocities at each point approaches the isotropic. Experimental results show the distribution near the solid walls to be anisotropic. When nearing the wall, the distribution appears increasingly two-dimensional and the components of fluctuating velocities, normal to the wall, decrease. The analogy between the approach used in the present theory and that of the kinetic theory of gases is pointed out.

EXPERIMENTAL INVESTIGATION IN MAGNETO-AERODYNAMICS. R. W. Ziemer. (ARS 13th Annual Meeting, New York, Nov. 17-21, 1958.) ARS J., Sept., 1959, pp. 642-647. 10 refs. Study of a 3-in.-diam. electromagnetic shock tube as a means of producing the hypervelocity and ionized air flow required for magnetoaerodynamic research. It is shown that although usable test times are only about 20 microsec., velocities up to 12,000 m./sec. and stagnation temperatures up to 25,000 K. are readily produced. The shock tube is used to study magnetoaerodynamic interaction in the ionized flow about a blunt body. Quantitative measurements are made of the change in the bow shock distance upon application of the magnetic field.

THE MAGNETOHYDRODYNAMIC FLOW PAST A FLAT PLATE. H. P. Greenspan and G. F. Carrier. J. Fluid Mech., July, 1959, pp. 77-96. Analysis of the uniform steady flow of an incompressible, viscous, electrically conducting fluid distorted by the presence of a symmetrically oriented semi-infinite flat plate. The ambient magnetic field is coincident with the ambient velocity field. The description of the resulting fields depends on the physical coordinates measured in units of Reynolds Number and on the two parameters $\epsilon$ and $\beta$. This description of the fields is approximated in three different ways and essentially covers the full range of $\epsilon$ and $\beta$. In particular, when $\beta \geq 1$, no steady flow which is uniform at large distances from the plate exists.

THE WAVE MOTIONS OF SMALL AMPLITUDE IN RADIATION-ELECTRO-MAGNETO-GAS DYNAMICS. S. I. Pai and A. I. Speth. U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-180 (AFOSR TN 59-879), July, 1959. 21 pp. Study of the fundamental equations of radiation electro-magneto-gasdynamics. These equations are linearized under the condition that there exists an externally applied uniform magnetic field. Wave motions of infinitesimal amplitude, which may be divided into a transverse wave and a longitudinal wave, are analyzed. Radiation phenomena exert influence only on the longitudinal wave, while the transverse wave is independent of the radiation field. The radiation effect is characterized by introducing a radiation parameter which is the ratio of radiation pressure to the gasdynamic pressure. For an ideal plasma, it may be expressed in terms of an effective radiation sound speed.

MAGNETODYNAMICS OF PLANE AND AXISYMMETRIC FLOWS OF A GAS WITH INFINITE ELECTRICAL CONDUCTIVITY. M. N. Kogan. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 70-80.) PMM - Appl. Math. & Mech., No. 1, 1959, pp. 92-106. Translation. Analysis showing that there exist two hyperbolic flow regimes, one of which occurs at subsonic velocities. In this flow regime, shock waves are inclined upstream. For



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certain values of the ratio between magnetic and hydrodynamic pressures, there exists an elliptic type of flow at supersonic velocities. In this regime weak shock waves do not occur, but strong shock waves are present whose angles of inclination start from the perpendicular. The simple waves for the hyperbolic regimes are constructed and the solutions are presented for the problem of flow around bodies in the linearized and second-order approximations.

THE QUASI-ONE-DIMENSIONAL FLOW OF AN ELECTRICAL CONDUCTING GAS FOR THE GENERATION OF ELECTRICAL POWER. G. W. Sutton. G-E MSVD TIS R59SD307 Aerophys. Res. Memo. 25, Feb. 9, 1959. 17 pp. Analysis of the inviscid flow equations of a conducting gas, deriving the relation between current, electrical field, and magnetic field for maximum power extraction. For this relationship, the equations are integrated analytically, assuming constant electrical conductivity and an ideal gas for the cases of constant velocity, constant area, constant temperature, constant pressure, and constant density. The constant velocity case is also considered for variable conductivity. The lengths required to extract 10% of the initial flow enthalpy are the same magnitude for moderate initial values of Mach Numbers; constant velocity flow yields the minimum length. The constant pressure flow has the least increase in cross-sectional area.

THEORY OF THE FLOW IN THE MAGNETIC ANNULAR SHOCK TUBE. N. H. Kemp and H. E. Petschek. Avco Everett Res. Lab. RR 60 (AFOSR TN 59-846), July, 1959. 35 pp. Analysis of the properties of the gas flow in the magnetic annular shock tube. This shock tube uses a magnetic field to drive a shock wave through an annular region, producing a very high temperature plasma. It is shown that this particular configuration allows a fairly precise calculation of the flow parameters. Numerical calculation of the significant flow properties for a complete range of the initial field strength and orientation are made and presented graphically.

DYNAMIQUE DES GAZ IONISES: DETERMINATION DES CHOCS STATIONNAIRES ATTACHES A LA POINTE D'UN DIEDRE. H. Cabannes. La Recherche Aéronautique, July-Aug., 1959, pp. 3-8. In French. Derivation of equations describing the shock phenomena in an infinitely conducting compressible fluid, and calculation of the stationary shock wave attached to the apex of a dihedral. The shock angle, the pressure, and the temperature over the dihedral are calculated for the zero electric field. Results show that the presence of a magnetic field increases the wake and reduces the temperature.

K TEORII UDARNYKH VOLN. G. Ia. Galin. AN SSSR Dokl., July 1, 1959, pp. 55-58. In Russian. Study covering the problem of (a) the existence of continuous solutions to systems of equations for media with an arbitrary equation of state and (b) the conditions resulting when shock transitions are considered as the limit to these continuous solutions. The results indicate that, in the case of shock transitions between the speed of sound c and the velocity of particles ahead and behind the shock wave, the condition $v_0 \geq c_0$, $v_1 \leq c_1$ must be satisfied. It is shown that the obtained results can be extended to the case of shock waves in solid bodies when the conditions along the wave are analogous to those used in gases.

LES AUTOPLISSEMENTS ET LES AUTO-ENROULEMENTS DYNAMIQUES DANS LES FLUIDES A VISCOSITE. François-Joseph Bourrières. France, Min. de l'Air NT 83, 1959. 14 pp. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 415. In French. Investigation of the permanent motion of viscous fluids using intrinsic equations (curvature radius, orthogonal trajectories at the lines). The two-dimensional "self-folding" phenomenon (jet, wake, wedge) is discussed, and the indefinite "self-curling up" is analyzed. The concept of constant-velocity fluid blade motion is used in the calculation.

## Internal Flow

THE DYNAMICS OF TURBO-FLOW. F. G. Gravalos. ZAMP, July 25, 1959, pp. 347-380. 11 refs. Analysis of the steady, axially symmetric flow of an inviscid, incompressible fluid through a turbomachine in terms of a proper definition of the force field, F, so as to represent a blade row, and the conditions of compatibility between the equation of continuity and the three Euler equations. Two generalizations of the potential force flows include the von Mises flow and the quasi-potential flow. The structure of the vorticity field is studied, and the problem of turboflow is reduced to two partial differential equations.

AN EXPERIMENTAL STUDY OF JET-FLAP COMPRESSOR BLADES. E. L. Clark, Jr., and D. E. Ordway. J. Aero/Space Sci., Nov., 1959, pp. 698-702, 738. 13 refs. Investigation to determine the feasibility of using the jet flap to improve the section characteristics of an axial-flow compressor blade. Internal design of the blade is described and details of the resulting jet flow are given. Also included are wind-tunnel design and test procedures for the two-dimensional cascade used in the test. Test results are presented in the form of the measured turning angle, pressure rise, and lift coefficient. They are examined with particular reference to the prevention of rotating stall.

AN ACTUATOR DISC ANALYSIS OF INLET DISTORTION AND ROTATING STALL IN AXIAL FLOW TURBOMACHINES. Hsuan Yeh. J. Aero/Space Sci., Nov., 1959, pp. 739-753. 14 refs. Analysis of the flow behind a rotor or stator blade row due to an arbitrary inlet distortion along both circumferential and spanwise directions. Numerical examples for the influence of various conventional design parameters, and an illustration of the role played by the cascade characteristics, represented by the variations of loss and exit flow angle due to changing inlet flow angles, are given. Using the same approach to the problem

of incipient stall, the analysis shows that theoretically there can be two types of self-induced distortion - a purely spanwise, asixymmetric type and a traveling, circumferential plus spanwise type.

PRESSURE DROP AND HEAT TRANSFER IN A DUCT WITH TRIANGULAR CROSS-SECTION. E. R. G. Eckert and T. F. Irvine, Jr. USAF WADC TR 59-222 [AD 214612], Apr., 1959. 56 pp. 10 refs. Measurement of friction factors in a duct with fully developed flow region for laminar, transitional, and turbulent conditions. In addition, local and average heat-transfer coefficients and the temperature field in the duct wall are determined for the condition of constant heat generation per unit volume of the duct walls.

ON THE REFLECTION OF WEAK DISCONTINUITIES FROM THE THROAT OF A LAVAL NOZZLE. O. S. Ryzhov and S. Iu. Cherniavskii. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 86-92.) PMM - Appl. Math. & Mech., No. 1, 1959, pp. 114-122. Translation. Analysis of three-dimensional flows of an ideal gas in Laval nozzles having discontinuities in the first derivatives of the velocity components on particular characteristic surfaces. The solutions obtained yield examples of transformations from three-dimensional gas flows into plane-parallel and axisymmetric flows, and also into other flows in space.

MIXING OF WAKES IN A TURBULENT SHEAR FLOW. Appendix - DISCUSSION ON WAKES AND JETS IN UNIFORM FREE STREAMS. Salamon Eskinazi. US, NASA TN D-83, Sept., 1959. 53 pp. 19 refs. Survey of measurements taken in the wake of a two-dimensional cylinder placed in a fully developed turbulent viscous layer inside a two-dimensional channel, and consisting mainly of the temporal mean velocity, static pressure distributions, turbulence velocity, and scale measurements. In the temporal-mean-velocity distribution, the mixing process shows transverse similarities to the free-stream mixing of turbulent and laminar wakes. Some discussions are included concerning the process of decay, when the wire is very near the wall and the wake spreads to the wall. The Reynolds Number of the flow in the channel based on the half-width of the channel and the space mean velocity is 86,000, and that of the cylinder based on its diameter and the space mean velocity is 2,240.

## Jet Flaps & Wings

ON THE THRUST HYPOTHESIS FOR THE JET FLAP INCLUDING MIXING EFFECTS. K. T. Yen. Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE 5902 (AFOSR TN 59-737), June, 1959. 33 pp. 11 refs. Study showing that, for an incompressible potential flow, the linearized jet flap problem is a linear combination of two problems: the lift problem and the thrust problem. The lift problem is the same as that formulated by Malavard, while the thrust problem is actually the thickness problem in the conventional terminology of thin airfoil theory. The mixing of the jet flap with the surrounding fluid is analyzed by the momentum integral method. The analysis substantiates Stratford's suggestion for obtaining an increase of thrust by causing the jet to mix with the main stream in a region of high suction. Finally, some approximate formulas relating the thrust and the jet angle are derived.

WIND-TUNNEL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF A MODEL REPRESENTATIVE OF A SUPERSONIC FIGHTER-CLASS AIRPLANE WITH AN EXTERNAL-FLOW JET-AUGMENTED FLAP IN LOW-SPEED FLIGHT. W. A. Newsom, Jr. US, NASA TN D-50, Sept., 1959. 84 pp. Description of tests on unswept wing models of aspect ratio 3.0 equipped with a full-span double slotted flap. An engine nacelle was strut mounted beneath each wing with jet diverted upward and outward toward the slot of the flap. Compressed air was used to represent the exhaust of these pod-mounted engines. The investigation was made for three different wing positions and two different horizontal-tail positions for each wing position, and included measurements of both longitudinal and lateral stability characteristics. Analysis indicates that for a supersonic fighter-class aircraft, simple downward deflection of the jet exhaust to provide a large vertical component of thrust could result in total lift coefficients (aerodynamic lift plus jet lift) of approximately the same magnitude as those obtained with jet-augmented flap.

## Performance

MINIMAL MANEUVERS OF HIGH-PERFORMANCE AIRCRAFT IN A VERTICAL PLANE. Angelo Miele. US, NASA TN D-155, Sept., 1959. 37 pp. 29 refs. Analysis of minimal maneuvers of high-performance aircraft in a vertical plane where the earth is assumed flat and the gravitational field uniform. The indirect methods of the calculus of variations are used and the variational problem formulated as a problem of Bolza type. Lagrange-type and Mayer-type problems are studied as particular cases. For the optimizing conditions, closed-form expressions can be derived, under particular assumptions, and applied to the calculation of the brachistocronic climbing technique of minimum time or of minimum fuel consumption for turbojet-powered or rocket-powered aircraft.

COMBINED OPERATIONS WITH AND WITHOUT AFTERBURNING FOR MINIMUM FUEL CONSUMPTION IN LEVEL FLIGHT. Angelo Miele and C. R. Cavoti. US, NASA TN D-151, Sept., 1959. 22 pp. Survey of problems of minimum fuel consumption and possibilities arising from combined operations with and without afterburning. The simple case of level flight is investigated and the optimizing conditions are determined. A general procedure is developed for computing the Mach Number at which the translation from nonafterburning operations to afterburning operations must occur. Several numerical examples are included, illustrating the general theory and supplying a tangible proof of the minimal character of the solution.



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APPROXIMATE SOLUTIONS TO OPTIMUM FLIGHT TRAJECTORIES FOR A TURBOJET-POWERED AIRCRAFT. Angelo Miele and J. O. Cappellari, Jr. US, NASA TN D-152, Sept., 1959. 33 pp. Analysis of the climbing program of a turbojet-powered aircraft with respect to minimum time, minimum fuel consumption, and minimum horizontal distance trajectories in flying from one speed-altitude combination to another. Trajectories minimizing any of the above three quantities are studied for the case where each of the other two is either free of choice or prescribed. It is shown that the totality of extremal arcs consists of a number of constant path inclination subarcs and a number of variable path inclination subarcs. For particular types of drag polars, the variable path inclination subarc may consist of several branches, one of which is subsonic, one transonic, and one supersonic. With regard to minimum time and minimum fuel consumption trajectories, only the subsonic and the supersonic branches are of interest. The effect of wing loading on the solutions is also investigated.

## Stability & Control

EFFECTS OF BODY AND FIN DEFLECTIONS ON THE AERODYNAMIC CHARACTERISTICS IN PITCH OF A 0.065-SCALE MODEL OF A FOUR-STAGE ROCKET CONFIGURATION AT MACH NUMBERS OF 1.41 AND 1.82. R. B. Robinson. US, NASA TN D-37, Sept., 1959. 33 pp. Investigation in the Langley 4-ft. x 4-ft. supersonic tunnel of a four-stage model with provision for deflecting each stage with respect to the next rearward stage. Cruciform fins are mounted on all but the final stage to give longitudinal and lateral stability and control. The results indicate that significant bending moments at the various stage junctures and appreciable attitude changes of the complete configuration can be caused by relatively small body deflection. With the fins aligned, the stability is increased in the low angle-of-attack range. Differential deflection of the second- or third-stage fins produces negligible rolling moments for both the aligned- and the indexed-fin configurations.

## Wings & Airfoils

EFFORTS D'UN FLUIDE INCOMPRESSIBLE SUR UN PROFIL OSCILLANT AUTOUR D'UNE INCIDENCE NON NULLE. G. Couchet. France, ONERA Pub. 96, 1959. 19 pp. In French. Presentation of a method for calculating the aerodynamic forces acting upon a profile oscillating in almost uniform translation in terms of incidence and thickness of the wing. It is found that, in the state of uniform translation, the incidence $\alpha$ of the wing is sufficiently small to neglect the $\alpha^3$ terms, and the profile is thin enough to neglect the second-order functions relating to the thickness.

BOUNDARY VALUE PROBLEMS IN LIFTING SURFACE THEORY. E. Van Spiegel. Netherlands, NLL Versl. & Verhandel. vol. XXII, TR W 1, Mar., 1959. 138 pp. 26 refs. Analysis considering the problem of a lifting surface of circular plan form in steady and unsteady incompressible flow with an arbitrary downwash distribution. A comparison of the regular velocity potential and the regular acceleration potential leads to a general expression for singular solutions of the Laplace equation. The complete solution for each of the physical problems is found as the sum of the regular acceleration potential and a singular solution, which is singular only along the leading edge of the wing. The resulting integral equations are then reduced to an infinite system of linear algebraic equations.

ESTIMATION OF THE INTERFERENCE WAVE DRAG BETWEEN SEPARATED COMPONENTS OF A WING-BODY COMBINATION. L. M. Sheppard and E. J. Moore. Australia, WRE TN HSA 44, Jan., 1959. 28 pp. Analysis of wave drag interference for components that are separated by a large distance, using a series expansion. Special consideration has been given to polynomial area distributions and an analytical expression for the interference wave drag has been obtained for the simplest type examined. Applications of the results have been made to wing drag vehicles with cylindrical center portions, and estimates are made of the nose-on-wing and wing-on-afterbody interference wave drag. In one case, the total interference wave drag was more than 10% of the total wing wave drag.

MEASURED AND PREDICTED SECTION WAVE DRAG COEFFICIENTS AT A MACH NUMBER OF 1.6 FOR A DELTA WING WITH TWO AIRFOIL SECTIONS. Appendix - CALCULATION OF SECTION DRAG COEFFICIENTS. F. C. Grant. US, NASA TN D-11, Sept., 1959. 41 pp. Presentation of wave drag characteristics for two airfoils with $60^{\circ}$ sweep and 6% thickness ratio. One wing had an NACA 65A006 section and the other had a section which produced a cross-sectional area distribution on the model identical to that of a Sears-Haack optimum body of revolution for given length and volume. Values of section drag computed by linear theory are compared with the experimental values.

THEORETICAL WAVE DRAG AT ZERO-LIFT OF SLENDER POLYHEDRAL WINGS. Appendix - TRANSFORMATION OF THE DRAG INTEGRAL. E. G. Cane. Gt. Brit., RAE TN Aero. 2501, Mar., 1959. 39 pp. Application of the linearized theory to determine expressions for the wave drag at zero-lift of uncambered, untwisted wings with a continuous first derivative of the cross-sectional area distribution. Calculated values for the drag of straight-tapered wings with tips parallel to the centerline and with double-wedge streamwise sections of constant thickness/chord ratio are given for a number of maximum thickness positions.

THE SECOND ORDER THEORY OF THE THREE-DIMENSIONAL THIN-WING-EXPANSION (T. Moriya Memorial Seminar). Michiya Sugo. Tokyo U. Fac. Eng. Dept. Aero. Res. Memo. 1, Feb., 1959. 28 pp. 13 refs. Analysis generalizing the second-order theory in the three-dimensional field, using an iteration process. With the mechanical iteration process, the second-order

solution has generally higher order singularities than the first-order group; this can be avoided by using the PLK method. Using the general solution, the pressure distribution is calculated for delta wings with subsonic and supersonic leading edges. The lift curve slope is also presented for the supersonic case. Comparison is made with other theories and an experiment.

NON-LINEAR SUPERSONIC CONICAL FLOW OVER FLAT PLATE DELTA WINGS. J. W. Brook. Grumman Aircraft Eng. Corp. Res. Dept. Rep. RE-117 [AD 219331], May, 1959. 110 pp. 15 refs. Presentation of a general method for obtaining the properties of the hyperbolic and elliptic regions of a delta wing, along with schemes for matching the two. It is shown that on the expansion side of the wing there exists a shock wave between the hyperbolic and elliptic regions. The various boundaries of the hyperbolic region are obtained on both the compression and expansion sides. The "double-hodograph" method is used for the numerical integration of the differential equation of motion in the elliptic region. The method of solution is presented for the transition from hyperbolic to elliptic flow.

## AEROELASTICITY

FLUTTER OF AN UNTAPERED WING ALLOWING FOR THERMAL EFFECTS. E. G. Broadbent. Gt. Brit., RAE Rep. Struc. 249, Apr., 1959. 14 pp. Analysis of the flutter problem of a thin rectangular solid steel wing of aspect ratio 3, considered with allowance for the reduction in stiffness due to thermal effects. The change in camber associated with wing bending gives rise to a destabilizing aerodynamic coupling which leads to a critical flutter Mach Number of just over 3.5; no other coupling in the same sense exists with the assumptions made, so that without this effect the flutter speed would be infinite. The root constraint is not important for a wing of the aspect ratio considered.

EFFECTS OF WING STIFFNESS CHANGES ON THE MODES AND FREQUENCIES OF A MODEL DELTA AIRCRAFT. D. R. B. Webb. Gt. Brit., RAE Rep. Struc. 245, Apr., 1959. 18 pp. Presentation of resonance tests showing the effects of stiffness changes in the leading and trailing edge spars on the frequencies and modes of vibration. The results indicate that, while considerable frequency changes were apparent, the general shape of the modes of vibration did not change significantly. The criterion of modal orthogonality proved to be useful in checking the purity of the modes. A minimum of two vibrators, whose force output could be independently varied, is found to be necessary to obtain good phase relationship between pick-up stations.

INVESTIGATION OF VIBRATION CHARACTERISTICS OF CIRCULAR-ARC MONOCOQUE BEAMS. W. B. Fichter and E. E. Kordes. US, NASA TN D-59, Sept., 1959. 27 pp. Presentation of experimental free-free vibration frequencies and nodal patterns of two 4%-thick monocoque beams which differed only in cover-sheet thickness, and comparisons between experimental and calculated beam frequencies. For the beam with thicker cover sheets, calculated frequencies were within 12% of the experimental frequencies for the first six bending modes and the first two torsion modes. For the other beam, comparable accuracies were obtained for only the first three bending modes.

## CONTROL THEORY

THE ANALYSIS AND DESIGN OF CONTINUOUS AND SAMPLED-DATA FEEDBACK CONTROL SYSTEMS WITH A SATURATION TYPE NONLINEARITY. S. F. Schmidt. US, NASA TN D-20, Aug., 1959. 106 pp. 16 refs. Derivation of methods for studying feedback control systems in which a saturation type nonlinearity occurs on the input to the plant, based on the assumption that the plant has one input and one output and may be determined by linear differential equations with constant coefficients. The root-locus and switch-time methods are used to determine nonlinear compensation functions to compensate for the undesirable effect of saturation. It is shown that a root-locus graph with respect to the limiter gain gives a qualitative indication of the system response as a function of input amplitude. Several aircraft autopilot examples with a limited rate of control-surface motion are also included.

## MATHEMATICS

### Numerical Analysis

ACTES DU COLLOQUE DE CALCUL NUMÉRIQUE. France, Min. de l'Air NT 80, 1959. 87 pp. 42 refs. SDIT, 2 Av. Porte-d'Issy, Paris 15, Frs. 1,800. In French. Compilation of eleven articles on numerical calculus covering the vectorial field, generating functions of certain punctual transformations, the distinction between the existence of the derivative and an analogous property, some theorems related to the Hurwitz determinants and to various other determinants involved in the theory of electric networks and servomechanisms, automatic computation of the determinants by the method of cycles, practical summation of the series, use of numerical calculus and graphical representations for defining the properties of the theory of generalized complex variables, certain aspects of the problem of representation of experimental phenomena, application of the least-square method to the smoothing of experimental curves, chronological series, and calculating machines.

## MECHANICS

K TEORII UPRUGIKH KOLEBANII TELA S ZHIDKOST'IU. N. N. Moiseev. AN SSSR Dokl., July 1, 1959, pp. 51-54. In Russian. Study of the vibrations of an elastic body containing a cavity partially or totally filled with liquid. The problem is reduced to that of a beam with a rectangular hardness axis. The motion of the liquid is assumed to be potential and the velocities and amplitudes of the waves infinitely small. The hamiltonian principle is used to derive the equations of motion, and the Ritz method is applied to the solution of eigenfunctions and frequencies.



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## MISSILES

THE MATHEMATICAL BASIS OF IMPACT PREDICTION FOR BALLISTIC MISSILES. Appendix A - EQUATIONS OF MOTION. Appendix B - AXIS TRANSFORMATION. Appendix C - THE SHAPE OF THE EARTH. R. W. Hynes. Australia, WRE TN TQD 20, Mar., 1959. 41 pp. Presentation of methods of predicting the "walking impact point" of a ballistic missile during its powered phase. Depending upon the requirements of accuracy and speed of response, as well as the nature of input data available, any of the proposed methods may be used in the design of an impact predictor. A summary of a complete set of equations for one particular method is also included.

DYNAMIC ANALYSIS OF A SIMPLE REENTRY MANEUVER FOR A LIFTING SATELLITE. F. C. Grant. US, NASA TN D-47, Sept., 1959. 35 pp. Presentation of calculated angles, times, distances, and accelerations associated with a simple one-skip maneuver to a glide trajectory. Wing loadings of 20 and 100 lbs. per sq. ft. are considered for re-entry angles up to $6^{\circ}$ with a lift-drag-ratio range of 1/2 to 5. Results are obtained by machine integrations of the motion for a radially symmetric earth and a static ARDC atmosphere. For the range of parameters considered, the limitations on the maneuver and the precision required are indicated.

AERODYNAMIC PROBLEMS OF MANNED SPACE VEHICLES. T. R. F. Nonweiler. (RAeS Meeting, London, Dec. 15, 1958.) RAeS J., Sept., 1959, pp. 521-528; Discussion, p. 530. Review of aerodynamic problems which may be of future interest covering, in particular, the need to limit the accelerations and retardations of man's passage, as well as the temperature of his environment. Problems arising during different stages between launching and return to earth are analyzed, and the various aspects included in the discussion are: limitations of the apogee heights; the shape, size, and mass of the vehicle; the heat transfer from the boundary layer; the effect of design variations on the heating rate; stabilization of the vehicle; suitable structural materials; unequal temperature distribution; physical properties of the external flow; clothing for protection from radiation and direct body cooling; means for changing the descent path for alleviating the decelerations; and the ejection capsule.

SEALED CABIN RELIABILITY AS RELATED TO STRUCTURE AND INTERNAL ATMOSPHERE. F. L. Dickey and G. H. Knipp. (ARS 13th Annual Meeting, New York, Nov. 17-21, 1958.) ARS J., Sept., 1959, pp. 656-661. 16 refs. Study of the advantages to the crew of an optimum internal atmosphere and pressure and the effects on a sealed cabin structure. The reliability of the cabin and its resistance to fast fracture are discussed and shown to be essentially constant for various internal pressures with proper design. Certain safety advantages of a cabin designed for high pressure are pointed out, for example, a greater resistance to meteoroid penetration and a longer decompression time should a penetration occur. Means of increasing the time of decompression to permit effective emergency action are discussed, and the need for complete reliability of the sealed cabin system is emphasized.

APPROXIMATE SOLUTIONS TO OPTIMUM CLIMBING TRAJECTORY FOR A ROCKET-POWERED AIRCRAFT. Appendix A - ON THE COMPOSITION OF EXTREMAL PATH WHEN INEQUALITY OF FORM $h_i \leqq h \leqq h_f$ IS IMPOSED ON VARIATIONAL PROBLEM. Appendix B - ANALYSIS OF TRANSITION SUBARC. Angelo Miele and J. O. Cappellari, Jr. US, NASA TN D-150, Sept., 1959. 56 pp. 15 refs. Analysis of the climbing program of a rocket-powered aircraft with regard to minimum time trajectories. Using the indirect methods of the calculus of variations, it is shown that the totality of extremal arcs is composed of a number of constant path inclination subarcs plus one variable path inclination subarc. A solution in a closed form is obtained for the variable path inclination subarc, and methods are developed for connecting the subarcs derived from Euler equations into the extremal arc minimizing the climbing time. The effect of wing loading or thrust loading on the solutions is also investigated.

USE OF AERODYNAMIC LIFT DURING ENTRY INTO THE EARTH'S ATMOSPHERE. Lester Lees, F. W. Hartwig, and C. B. Cohen. (ARS Controllable Satellites Conf., Cambridge, Apr. 30-May 1, 1959.) ARS J., Sept., 1959, pp. 633-641. Study concluding that aerodynamic lift employed during entry into the earth's atmosphere at either orbital or escape velocity increases the range of allowable entry angles for a prescribed peak deceleration, while total heat energy transferred to the vehicle can be held to about the same value as for a non-lifting vehicle. Only modest lift-drag ratios are required beyond peak G (deceleration experienced by an accelerometer, g) to prevent the deceleration from initially exceeding the peak value, or to prevent the vehicle from skipping out of the earth's atmosphere. Thus, the difficult guidance and control problem is greatly alleviated; in particular, for return from the moon or other planets, the necessity for multiple-pass drag braking is eliminated.

MINIMUM PROPULSION FOR SOFT MOON LANDING OF INSTRUMENTS. Appendix I - SIMPLIFIED ANALYSIS; IDEAL VEHICLE; VERTICAL DESCENT. Appendix II - IDEAL ROCKET ENGINE. Appendix III - MASS OF THRUST CHAMBER - LIQUID PROPELLANT ENGINES. Appendix IV - COMPONENT MASSES - LIQUID PROPELLANT SYSTEMS. Appendix V - MASS OF THRUST CHAMBER - SOLID PROPELLANT UNIT. Appendix VI - COMPLETE IDEAL VEHICLE ANALYSIS. D. S. Carton. Coll. of Aeronautics, Cranfield, Note No. 94, July, 1959. 38 pp. Analysis to determine the approximate size scale for a moon landing vehicle and its propulsion system, considering a 100 lb. payload. In addition, earth-moon trajectories and various approach and landing techniques are discussed. Some 22 sets of scaling constants are derived for six liquids and

one hypothetical solid propellant, but only six sets are applied to minimum vehicle mass calculations. It is shown that considerable mass advantage is obtained by using liquid propellants, and that more work is required on the combined effects of combustion pressure, expansion ratio, and mixture ratio.

A NEW METHOD OF SOLUTION FOR UNRETARDED SATELLITE ORBITS. J. P. Vinti. US, NBS Rep. 6449 (AFOSR TN 59-608) [AD 217395], July 1, 1959. 23 pp. 10 refs. Presentation of an axially symmetric solution of Laplace's equation in oblate spherical coordinates which may be used as the gravitational potential about an oblate planet. This potential, which makes the Hamilton-Jacobi equation for a satellite orbit separable, has an expansion in zonal harmonics in which the amplitudes of the zeroth and second harmonics can be adjusted to agree exactly with the values for any axially symmetric planet, and a fourth harmonic which then agrees approximately with the latest value for that of the earth. The net result is a reduction of the problem of satellite motion to quadratures, with the use of a potential field that is much closer to the empirically accepted one for the earth than any heretofore used as the starting point of a calculation.

GRAVITY TORQUE ON AN ORBITING VEHICLE. Appendix - ALTERNATE DERIVATION OF POTENTIAL ENERGY FUNCTION. B. F. Doolin. US, NASA TN D-70, Sept., 1959. 45 pp. 11 refs. Derivation of the potential energy of a small body moving under the influence of only the earth's gravity field. It is shown that the effects of earth and body oblateness are separate to terms of second order in the potential energy function. The invariance of the potential energy under orthogonal transformations is discussed and is used to simplify calculations of the terms in the potential function. The equations of motion of the vehicle are obtained in generalized and in body coordinates. The components of torque in body coordinates are obtained by a transformation determined by the invariance of rotational power. Two applications of the equations of motion in body coordinates are made. They are first used to show that an energy integral does not exist for these equations since they are derived with respect to the satellite mass center. Then, they are applied in simplified form to an examination of the stability of a vehicle in a circular orbit.

## POWER PLANTS

METODOS DE PROPULSION EN ASTRONAUTICA. S. S. Aranguez. Ing. Aero. & Astronáutica, May-June, 1959, pp. 13-30. 22 refs. In Spanish. Survey of various types of propulsion systems in astronautics, and presentation of characteristic data for chemical and nonchemical rockets. An outline of rocket fuels is given and basic parameters, such as specific impulse, thrust/total weight ratio, and specific weight of the power plant are studied. A discussion of a proposed manned space station established by means of the Atlas ICBM is also included.

### Jet & Turbine

K TEORII PEREKHODNYKH (NEUSTANOVIVSHIKHSIA) REZHIMOV GAZOTURBINNYKH DVIGATELEI. Iu. P. Nikolaev. AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom., May-June, 1959, pp. 95-99. In Russian. Determination of generalized dynamic characteristics of gas turbines for the nonsteady operating regime. The quasi-steady character of transient regimes in gas-turbine engines allows the equation of motion for this type of power plant to be expressed in terms of dimensionless parameters and the dynamic characteristics to be expressed as a single generalized field containing all the arbitrary states and transient regimes. The dynamic properties of the practical gas-turbine power plant are determinated by means of the dynamic parameters $K_n$ and $K_N$, characteristic of the values of acceleration and excessive power of the rotor in the equivalent transient regime. In the case of given external conditions, these dynamic parameters depend only on the number of revolutions of the rotor.

### Rocket

ANALYSIS OF INJECTION-VELOCITY EFFECTS ON ROCKET MOTOR DYNAMICS AND STABILITY. H. G. Hurrell. US, NASA TR R-43, Sept., 1959. 40 pp. 22 refs. Introduction to a concept of combustion time lag including the dependency on injection velocity. The concept is used in the formulation of chamber transfer functions and analysis of low-frequency combustion instability. Theoretical frequency responses and stability boundaries are compared with those obtained when the injection-velocity sensitivity is neglected. These comparisons show the injection-velocity effect on the time lag to be an important consideration in the theory of chamber dynamics and combustion instability.

ANALYSIS OF EFFECTS OF ROCKET-ENGINE DESIGN PARAMETERS ON REGENERATIVE-COOLING CAPABILITIES OF SEVERAL PROPELLANTS. A. N. Curren, H. G. Price, Jr., and H. W. Douglass. US, NASA TN D-66, Sept., 1959. 47 pp. 25 refs. Analysis concerning the regenerative-cooling requirements of rocket-engines using high-energy liquid propellants. The propellant combinations are $H_2$-$F_2$, $H_2$-$O_2$, $N_2H_4$-$F_2$, $NH_3$-$F_2$, and JP4-$O_2$. Each of the seven major design parameters is varied independently to evaluate its significance in cooling considerations. In general, propellant combinations using hydrogen as the fuel and coolant display the best cooling possibilities. The most important influencing parameters with respect to the cooling requirement of a particular propellant combination, in approximate order of decreasing influence, are engine size, performance efficiency, fuel-oxidant mixture ratio, expansion area ratio, combustion-chamber pressure, and contraction area ratio.

PROPELLANT VAPORIZATION AS A CRITERION FOR ROCKET-ENGINE DESIGN; EXPERIMENTAL EFFECT OF CHAMBER DIAMETER ON LIQUID OXYGEN - HEPTANE PERFORMANCE.



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M. F. Heidmann. US, NASA TN D-65, Sept., 1959. 22 pp. Evaluation of the effect of combustor gas velocity on the performance of a pair of impinging heptane jets reacting in a highly atomized oxygen atmosphere in a nominal 200-lbs. thrust combustor. Contraction-ratio changes resulting from variations in chamber diameter are used to vary combustor gas velocity. In combustors less than 10 in. long, highest performance is obtained with the large-contraction-ratio combustors. In chambers greater than 10 in. long, the reverse trend of performance with contraction ratio is observed. A direct comparison of this experimental effect and the analytical effect presented in the literature shows that the experimental reversal occurred in a longer chamber and at higher performance than predicted.

DESIGN OF AXISYMMETRIC EXHAUST NOZZLES BY METHOD OF CHARACTERISTICS INCORPORATING A VARIABLE ISENTROPIC EXPONENT. Eleanor Costilow Guentert and H. E. Neumann. US, NASA TR R-33, Sept., 1959. 31 pp. 11 refs. Development of an analytical method for including thermodynamic data with variable isentropic exponent in the method of characteristics as applied to the design of high-temperature, bell-shaped exhaust nozzles. A comparison of nozzle contours obtained by assuming identical boundary conditions and either frozen or equilibrium composition shows that important differences occur. A computation of the variation of vacuum specific impulse with axial length revealed that considerable nozzle length, and hence weight, can be eliminated without serious thrust penalties in nozzle designs that gradually expand the flow to uniform exit conditions.

## RESEARCH, RESEARCH FACILITIES

### Wind Tunnels

EXPERIMENTAL FACILITIES AND MEASURING TECHNIQUES. D. W. Holder. (RAeS Meeting, London, Dec. 15, 1958.) RAeS J., Sept., 1959, pp. 493-502; Discussion, pp. 528, 529. 43 refs. Survey of experimental facilities and measuring techniques for the research encompassing aerodynamic problems arising in hypersonic flight. The extent to which these test facilities can reproduce the conditions of full-scale hypersonic flight is evaluated, and the important aerodynamic parameters, such as the Mach and Reynolds Numbers, the specific enthalpy, and the density, are listed. The survey covers facilities with long running times, such as the hypersonic wind tunnels, and those with short running times, including gun tunnels, shock tubes, shock tunnels, and "hotshot" tunnels.

EXPERIMENTELLE HYPERSCHALLFORSCHUNG. Herbert Oertel. (DGRR Internatl. Fachtagung Raketentech. & Astron., Essen, Oct., 1958.) Raketentech. & Raumfahrtforsch., July-Sept., 1959, pp. 65-75. 47 refs. In German. Survey of experimental techniques used to produce hypersonic flows up to a Mach Number of 20. Includes description of the instrumentation used in shock tube measurements, as well as methods for measuring pressure distribution, Mach Number, pitot pressure, and heat transfer. A light-gas gun for determining the flight velocity of a model is discussed, and special techniques developed for calculating the flow density, the speed of propagation of the shock front, as well as the flow velocity within the tube, are presented.

STUDY OF TRANSONIC WIND TUNNEL FLOW. Duvvri Tirumalesa. Aero. Soc. India J., May, 1959, pp. 30-43. Investigation of transonic flow in a wind tunnel with perforated walls. In the lower transonic region ($M \leqslant 1$) the flow is generated in two ways: first, by varying the compressor rotation, and then by a downstream adjustable sonic throat. In order to attain the free air condition of the same speed upstream and downstream of the model, a mobile flap at the downstream end of the perforated plate is used. This flap helps to control the amount of secondary flow. In the upper transonic region ($1 < M \leqslant 1.3$), a nozzle is developed to obtain Mach Numbers between 1 and 3. The optimum distribution of the perforations along the test section length to obtain sufficiently uniform flow at different Mach Numbers is studied. Results are presented for airfoil studies made in various regions.

SUR QUELQUES APPLICATIONS ACTUELLES DE L'ANALOGIE HYDRAULIQUE. J. Le Manach and E. Robert. La Recherche Aéronautique, July-Aug., 1959, pp. 41-44. In French. Application of the hydraulic analogy method to three specific cases in order to illustrate its role in transonic and supersonic research. The examples presented cover ram-jet air intakes, ignition in combustion chambers, and kinetic heating. The models used in the investigation are described along with respective test conditions, and the experimental results are presented.

THE PRODUCTION AND STUDY OF HIGH SPEED SHOCK WAVES IN A MAGNETIC ANNULAR SHOCK TUBE. R. M. Patrick. Avco Everett Res. Lab. RR 59, July, 1959. 36 pp. 15 refs. Survey of the development of a magnetic annular shock tube and preliminary experimental investigation of the structure of very-high-speed shock waves produced by means of two magnetic field configurations ahead of the shock front in the tube. The continuum radiation emitted by the shock-heated plasma is measured with photomultipliers, and the use of probes to measure the change in the local magnetic field in the shock front is studied. For high-speed shock waves, a shock thickness is obtained from measured rise times of the emitted visible radiation, and it is found that the shock thicknesses are less than the mean free path in the shock-heated plasma.

METHODS OF MEASUREMENT OF AIRCRAFT DYNAMIC STABILITY DERIVATIVES. K. Orlik-Rückemann. Canada, NRC Aero. Rep. LR-254, July, 1959. 37 pp. 203 refs. Presentation and classification of numerous methods available for determination of dynamic stability derivatives of aircraft. Free-flight, full-scale flight, and wind-



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tunnel methods are considered. The cases of oscillatory and rotational derivatives are covered separately, as different methods are required for their measurement even though their actual values may be approximately the same. The basic aspects of each method are described and illustrated by a schematic drawing.

## ROTATING WING AIRCRAFT, HELICOPTERS

AN EVALUATION OF LINEARIZED VORTEX THEORY AS APPLIED TO SINGLE AND MULTIPLE ROTORS HOVERING IN AND OUT OF GROUND EFFECT. Appendix A - DERIVATION OF EQUATIONS FOR INDUCED VELOCITIES. Appendix B - EFFECT OF NONUNIFORM DISK LOADING. Appendix C - EFFECT ON INDUCED POWER OF TWIN-ROTOR HELICOPTERS. H. H. Heyson. US, NASA TN D-43, Sept., 1959. 60 pp. 21 refs. Investigation showing that differences between the actual and the simplified theoretical wake patterns may lead to large errors in the calculated flow, particularly at points outside the rotor wake. In particular, the results of hovering tests of a two-rotor configuration in ground effect do not show the large, favorable interference effects predicted by theory. Correlation of these results with available flow studies indicates that there are some regions of the flow field of a single rotor, primarily within the wake, where the theory yields reasonable qualitative results which can be used for ground-effect and download calculations.

## STRUCTURES

### Beams & Columns

THEORETICAL ANALYSIS OF THE CREEP COLLAPSE OF COLUMNS. Appendix - ASYMPTOTIC FORMULAS FOR EXTREME VALUES OF INITIAL LATERAL-DISPLACEMENT PARAMETER. F. R. Schlechte. US, NASA TN D-95, Sept., 1959. 46 pp. 14 refs. Application of a creep variational theorem to the analysis of idealized H-section columns and solid rectangular-section columns. For the rectangular-section columns the stress distribution through the thickness is assumed to be linear in one case and nonlinear in another. Comparisons are made between the theories for the rectangular-section columns and previously published data. These comparisons indicate that the linear-stress theory gives nearly the same result as the nonlinear-stress theory. In many cases, the results obtained by means of the isochronous-tangent-modulus method are about as good as the results obtained from more involved theoretical methods.

### Cylinders & Shells

THE BUCKLING OF A PRESSURISED STIFFENED CYLINDER UNDER AXIAL LOAD. K. I. McKenzie. Gt. Brit., RAE Rep. Struc. 247, Apr., 1959. 25 pp. Analysis considering torsional buckling of the complete cylinder, local buckling of the stringers, and pure compressive failure of the stringers. It is concluded that for cylinder stability it is best to have the material equally divided between skin and stringers. An example of an optimum design to withstand a given axial load is presented.

INTEGRODIFFERENTIAL AND INTEGRAL EQUATIONS OF EQUILIBRIUM OF THIN ELASTIC SHELLS. N. A. Kil'chevski. (Prikl. Mat. i Mekh., Jan.-Feb., 1959, pp. 124-133.) PMM - Appl. Math. & Mech., No. 1, 1959, pp. 165-178. Translation. Presentation of a method based on application of the work reciprocity theorem for deriving equations of equilibrium of thin elastic shells in terms of displacements. This is a modification of the Somiglian method, differing by a special choice of the system of the auxiliary displacements; this choice permits the representation of the displacement of a point on the middle surface of the shell by the sum of two displacements.

RÓWNANIA NAPRĘŻEŃ PRZY OBCIĄGANIU I CIĄGNIENIU CIENKICH POWŁOK O PODWÓJNEJ KRZYWIŹNIE. Wojciech Szczepiński. Arch. Budowy Maszyn, No. 2, 1959, pp. 325-343. In Polish, with summaries in English and Russian. Development of stress equations for stretch-forming and drawing of thin shells with double curvature. The problem is solved under the Huber-Mises plasticity condition for all cases of drawing or under the Tresca condition for those cases in which the two main stresses have opposite signs. Application is made to the case of drawing a shell in a mold shaped as a one-shell hyperboloid. The problem is reduced to successive solutions of the Cauchy problem, mixed problems, and the Riemann problem for the differential equations of characteristics.

THE EFFECT OF AXIAL CONSTRAINT ON THE INSTABILITY OF THIN CYLINDRICAL SHELLS UNDER EXTERNAL PRESSURE. Josef Singer. Technion, Israel Inst. Tech. Dept. Aero. Eng. Rep. 2, May, 1959. 16 pp. EOARDC-sponsored analysis of a cylindrical shell under uniform lateral pressure using a Rayleigh-Ritz approach. For the case of hydrostatic pressure the effect is calculated for a wide range of parameters, and design curves are presented for the per cent of increase in critical pressure.

SIMPLIFIED EQUATIONS FOR THIN CIRCULAR CONICAL SHELLS UNDER ARBITRARY LOADS AND ARBITRARY TEMPERATURE DISTRIBUTIONS. Josef Singer. Technion, Israel Inst. Tech. Dept. Aero. Eng. Rep. 4, June, 1959. 15 pp. EOARDC-sponsored derivation of simplified differential equations governing the deformation of circular conical shells using the principle of the minimum total potential energy. The equations reduce to Donnell's equations (extended to include an arbitrary temperature distribution) when the cone angle approaches zero. For convenience, the equations are also given for particular types of temperature distributions and for zero temperature rise.

POWŁOKA OBROTOWA ZE WSPÓŁŚRODKOWYM OTWOREM WIERZCHOŁKOWYM, WZMOCNIONYM PIERŚCIENIEM, OBCIĄŻONYM SIŁĄ

SKUPIONĄ. Andrzej Jaworski. Arch. Budowy Maszyn, No. 2, 1959, pp. 279-306. In Polish, with summaries in English and Russian. Analysis of a shell of revolution with a central top cutout reinforced by a ring rigid to bending and torsion and subject to the action of an arbitrarily directed concentrated force. The assumption of the stress distribution corresponding to the membrane theory is made, permitting the calculation of the stress-resultant at any point of the shell if the stress resultants on a certain parallel are known. Expanding in a Fourier series the boundary stress-resultants on the ring parallel and considering the equilibrium of the ring under the action of an external force, two statically indeterminate, self-equilibrated harmonics $t_n$ and $s_n$ are found. Expressing all internal forces in the shell and in the ring as functions $t_n$ and $s_n$, the expression for the elastic energy of the whole system is found.

THE ANALYSIS OF FUSELAGES OF ARBITRARY CROSS-SECTION AND TAPER. VI. J. H. Argyris and S. Kelsey. Aircraft Eng., Aug., 1959, pp. 244-256. Compilation of the derived data matrices established previously for the basic system in order to give the compatibility equations from whose solution the redundancies are obtained. The general solution of the compatibility equations leads to the complete stress distribution and deformation of the regularized fuselage due to external loads, wing or tail interaction redundancies, and to thermal strains. From these, by the use of the cut-out and modification technique, the corresponding results for the actual fuselage as an independent structure are obtained. The interaction redundancies at the wing and tail unit attachments are determined on the assumption that these components are also analyzed by the force method. Hence, the final stress distribution is obtained for the fuselage as an integral part of the complete aircraft structure.

## Elasticity & Plasticity

OB IZOTROPNOM UPROCHNENII PLASTICHESKIKH TEL. D. D. Ivlev. AN SSSR Dokl., Aug. 1, 1959, pp. 777-779. In Russian. Analysis covering the theory of plasticity and the possibility of taking the isotropic hardening into account. In the case considered, the relationship between stresses and speeds of deformation are determined from the condition of coincidence of stress tensors and speeds of deformation. Therefore, in the case of closed systems defining the stress and the speed of deformation, the thermodynamic ratio can be considered separately. Various methods for determining the degree of hardening are indicated, and the plastic flow is considered for axisymmetric and three-dimensional cases.

## Fatigue

STATISTICAL ANALYSIS OF SEAPLANE FATIGUE. J. E. Pauken. Aero/Space Engrg., Nov., 1959, pp. 63-67. Study of a number of failures which occurred in the bottom plating of the planing area of the hull, where high-frequency water pressure loadings are experienced during landing and take off. For a statistical solution, the magnitude and the number of pressure cycles experienced in service and the fatigue strength of the plating are required. Experimental flight tests provided the pressure data, and fatigue tests on small specimens provided data on the latter. A damage study is made by comparing the applied pressure load spectrum with the allowable fatigue strength of the bottom structure using Miner's cumulative damage theory.

## Plates

ZAGADNIENIE ROZKŁADU NAPRĘŻEŃ W ŚCISKANEJ PŁYCIE PROSTOKĄTNEJ PODDANEJ JEDNOCZESNEMU DZIAŁANIU OBCIĄŻENIA POPRZECZNEGO. Jerzy Leyko. Arch. Budowy Maszyn, No. 2, 1959, pp. 259-277. In Polish, with summaries in English and Russian. Analysis of the distribution of stresses in a rectangular plate subject to compression and simultaneously loaded by a perpendicular force to the middle surface. The results show that the effect of transverse load on the reduction coefficient is equal to the ratio of the mean compression stress to the maximum stress in the center part of the plate. Even a slight transverse load causes a distinct decrease in the reduction coefficient. The disturbance method is used to determine the second approximation of the reduction coefficient for a plate subject only to compression. Detailed calculations performed for a square plate imply that formulas thus obtained give values of the reduction coefficient that are lower, and thus in better agreement with experiments than those given by the formulas in general use.

## Sandwich Construction

OPTIMUM PROPORTIONS OF TRUSS-CORE AND WEB-CORE SANDWICH PLATES LOADED IN COMPRESSION. M. S. Anderson. US, NASA TN D-98, Sept., 1959. 26 pp. Presentation of the proportions of truss-core and web-core sandwiches which give the minimum weight for carrying in-plane compressive loads. For lightly loaded sandwich plates, the truss-core sandwich is less efficient than honeycomb sandwich, but for higher loading intensities, the truss-core sandwich is most efficient. The web-core sandwich is not as efficient as honeycomb or truss-core sandwich.

## Thermal Stress

EFFECT OF CHORDWISE HEAT CONDUCTION ON THE TORSIONAL STIFFNESS OF A DIAMOND-SHAPED WING SUBJECTED TO A CONSTANT HEAT INPUT. R. G. Thomson and J. L. Sanders, Jr. US, NASA TN D-38, Sept., 1959. 34 pp. Analysis of the reduction in torsional stiffness of a wing due to a suddenly applied constant heat input, considering chordwise heat conduction. Analytic solutions are obtained by using separation of variables and Mellin transforms, and the computed results are given in graphical form. The effect of chordwise heat conduction in reducing the temperature gradients is greatest near the leading and trailing edges of the wing. The dependence of torsional



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stiffness reduction on the heating rate and the final wing temperature is inferred from the results obtained.

### Wings

THE STRESS DISTRIBUTION IN A SWEPT-BACK BOX-BEAM UNDER TORSIONAL AND BENDING LOADS. Ken Ikeda and Megumi Sunakawa. U. Tokyo Aero. Res. Inst. Rep. 347, July, 1959. 11 pp. Presentation of an approximate solution using the method for statically indeterminate structural analysis for the case of stresses in swept-back box-beams having asymmetrical section. The box-beam is assumed to consist of four concentrated flanges of different cross-sectional area and four thin walls of different thickness connecting the flanges. The ribs are assumed perfectly stiff except the one nearest to the root. In the analysis, the ribs parallel to the air stream are replaced by those perpendicular to the spars. Cases analyzed include the following: tip concentrated torsional load, bending moment due to tip load, tip load only on the front spar, and tip load only on the rear spar.

HANDBOOK OF STRUCTURAL STABILITY. VII - STRENGTH OF THIN-WING CONSTRUCTION. George Gerard and Herbert Becker. US, NASA TN D-162, Sept., 1959. 83 pp. 51 refs. Discussion of the orthotropic plate theory applicable to the determination of the stability of various forms of stiffened and sandwich plates to be used for the compression covers of thin wings. Design charts are presented and methods of evaluating the elastic constants associated with each type of plate are reviewed. Buckling and failure of multiweb, multipost, and multipost-stiffened forms of beam construction are studied in terms of available theoretical and experimental results.

## THERMODYNAMICS

HIGH TEMPERATURE HEAT TRANSFER TO TUBES AND NOZZLES. Appendix A - TUNNEL HEAT LOSS CALCULATIONS. Appendix B - GENERAL CONSIDERATIONS ON EXPERIMENTATION AND DATA REDUCTION. I. E. Kanter, F. Martinek, M. L. Ghai, D. Namkoong, and J. Loch. G-E FPLD Rep. (AFOSR TN 59-488) [AD 215841], Feb., 1959. 128 pp. 43 refs. Discussion of the operation of a gas-stabilized plasma generator working with nitrogen gas and water-cooled metal electrodes to supply the necessary hot gas. The described instrumentation is suitable for measuring the various temperatures, flow velocities, and power consumption rates experienced with the generator and associated equipment. Temperature traverses and photographic studies are made to investigate the flow field of the effluent gas. Finally, calculations are presented for the thermodynamic properties of nitrogen gas at high temperatures, including the pressure effect.

TEMPERATURA AZOTA I VOZDUKHA ZA UDARNOI VOLNOI. F. S. Faizullov, N. N. Sobolev, and E. M. Kudriavtsev. AN SSSR Dokl., July 21, 1959, pp. 541-544. In Russian. Evaluation of experimental results on the temperature of air and nitrogen behind a shock wave obtained by using the method of conversion of spectral lines with photoelectric recording. A satisfactory agreement is found between theory and experiment. The problem of temperature distribution along the region of highly heated gas (plug) observed between the shock wave front and the contact surface separating the sections of high and low pressure in a shock tube is covered. The method of ionization was applied to measure the speed of the shock wave, using hydrogen as the accelerating gas. The temperature was measured by the conversion of sodium D-lines. The results indicate that, only in the case of relatively small wave velocities, the recorded temperature is constant along a part of the theoretical length of the plug.

### Combustion

COMBUSTION OF FUEL SPRAYS. G. Millán, I. Da Riva, and S. Sanz. Inst. Nac. Tec. Aero. Esteban Terradas Rep. (AFOSR TN 59-629) [AD 217814], Jan. 31, 1959. 27 pp. Analysis of the combustion of a fuel spray burning in an oxidizing atmosphere. Various typical cases, such as starting and stopping of the injection, continuous functioning, and periodical injections of short duration are studied. The Rosin-Rammler function of size distribution, used by Probert, is substituted by that of Mugele-Evans which, by limiting the maximum size of the droplets, yields a better approximation for the real distributions.

TWO CASES OF UNSTABLE COMBUSTION. K. I. Shchelkin. (Zhurnal Teoret. i Exper. Fiz., Feb., 1959, pp. 600-606.) Sov. Phys. - JETP, Aug., 1959, pp. 416-420. Translation. Derivation of a criterion for instability of the flame zone of a plane detonation wave, the criterion determining the conditions for the occurrence of spin detonation. It is shown that the criterion for unstable combustion, which is derived for detonation waves, is also applicable to forced combustion chambers. The instability of the flame zone plane is considered as a source of high-frequency oscillations of the flame. The order of magnitude of the fundamental frequency of these oscillations has been determined, and the conditions for the appearance of higher harmonics have been found.

O SVIAZI MEZHDU ZNACHENIIAMI TEMPERATURY PLAMENI, IZMERENNOI OPTICHESKIMI I DRUGIMI METODAMI. K. P. Vlasov. AN SSSR Otd. Tekh. Nauk Izv. Energ. i Avtom., May-June, 1959, pp. 100-103. In Russian. Application of optical methods, such as those involving conversion of spectral lines and the use of infrared pyrometers, to the measurement of turbulent flame temperatures. On the basis of optical techniques, a relationship between the mean thermodynamic temperature and temperatures from optical methods is determined. The values of the combustion-chamber temperature measured by the method of spectral-line reduction lead to the calculation of mean-square values of the fluctuating temperature due to the frequently observed insufficient micromixing of fuel and air.

that satellite orbit variations depended to some extent on the arrival of particles from the sun, and that the atmosphere of the auroral zones was actually warmer than the upper atmosphere at temperate and equatorial latitudes.

**Micrometeorite Measurements from 1958 Alpha and Gamma Satellites.** E. R. Manring. *Planetary & Space Sci.*, Jan., 1959, pp. 27–31. Presentation of data obtained from 1958 Alpha and Gamma satellites, and discussion of possible reasons for premature failure of satellite electronics.

**Some Deductions of Ionospheric Information from the Observations of Emissions from Satellite 1957α2. I—The Theory of the Analysis. II—Experimental Procedure and Results.** G. J. Aitchison, J. H. Thomson, and K. Weekes. *J. Atmos. & Terrestrial Phys.*, June, 1959, pp. 236–248.

**Synoptic Variation of the Radio Refractive Index.** B. R. Bean and L. P. Riggs. *J. Res., Sect. D - RP*, July-Aug., 1959, pp. 91–97. 12 refs. Study of synoptic variation evaluated from standard weather observations during an outbreak of polar continental air.

**The Radio Galaxy.** Gart Westerhout. *Sci. Am.*, Aug., 1959, pp. 45–51. Discussion of the technique applying radio astronomy to the mapping of galaxies.

**Research Directed Toward the Study of "Middle Latitude Magnetic Activity."** Daniel Linehan. *Boston Coll. Paper (AFCRC TR 59-226) [AD 212266]*, Oct., 1958. 7 pp.

**On Hydrogen Emission in the Night Glow.** I. S. Shklovsky. *Planetary & Space Sci.*, Jan., 1959, pp. 63–65.

**Some Indices of Solar Activity Based on Ionospheric and Radio Noise Measurements.** C. M. Minnis and G. H. Bazzard. *J. Atmos. & Terrestrial Phys.*, June, 1959, pp. 213–228. 10 refs.

**On the Origin of Terrestrial Particles from Solar Flares.** W. H. Ward. *J. Atmos. & Terrestrial Phys.*, June, 1959, pp. 296–298. Discussion of a mechanism which might lead to ejection of charged particles from the sun. It arises from the local cancellation of the magnetic field of a pair of sunspots by a general field.

**Geomagnetic Activity Following Large Solar Flares.** C. S. Warwick and R. T. Hansen. *J. Atmos. & Terrestrial Phys.*, June, 1959, pp. 287–295.

**Cosmic Radiation Measured on the Second Artificial Satellite.** S. N. Vernov, N. L. Grigorov, Iu. I. Logachev, and A. E. Chudakov. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 617–619. Translation.

**On the Response of a Single Large Scintillator to Extensive Air Showers.** J. R. Green. *U. New Mexico Dept. Phys. Rep. (AFOSR TN 59-490) [AD 215943]*, May 4, 1959. 25 pp. 14 refs.

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### Connections

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**Integral'nye Uravneniia Ravnovesiia Tonkikh Uprugikh Tsilindricheskikh Obolochek.** N. I. Remizova. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 611–615. In Russian. Analysis of a general method developed for the solution of static problems in the theory of shells, based on the reduction of this problem to the solution of a certain system of integral equations. Results of the application of this method to the case of thin, elastic cylindrical shells are presented.

**Ob Odnoi Avtomodel'noi Dinamicheskoi Zadache dlia Konicheskoi Obolochki.** I. S. Gerasimov. *AN SSSR Dokl.*, Apr. 11, 1959, pp. 989–991. In Russian. Study of a circular elastic conical shell subjected to a moving load expanding at a constant speed $v$ from the apex of the cone along its axis of symmetry. The thickness of the shell is a linear function of the distance from the apex.

**Beitrag zur lückenlosen Bestimmung des Eigenspannungszustandes in metallischen Hohlzylindern.** Pierre Laurent and Georg Altmeyer. *Forschung Gebiete Ing., Ausg. A*, No. 2, 1959, pp. 44–54. 12 refs. In German. Analysis of the state of residual stress in hollow cylinders based on the stress/strain relation derived by Sachs.

**Stability of Inhomogeneous Elasto-Plastic Shells.** E. I. Grigoliuk. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 438–441. Translation. Derivation of a formula for determining the critical forces of the local stability loss under combined loading.

### Elasticity & Plasticity

**Diffraction of a Plane Elastic Wave at the Vertex of a Sector.** V. A. Sveklo and V. A. Siukiiainen. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 451, 452. Translation.

**O Rasprostranenii Uprugo-Plasticheskikh Voln v Poluprostranstve.** Kh. A. Rakhmatulin. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 419–424. In Russian. Development of an approximate method for solving the problem of elastoplastic waves propagating in a semispace with a given normal pressure along the boundary $z = 0$. Three specific examples are analyzed, and the state of stress in the neighborhood of the load boundary is calculated.

**Reflection and Refraction of an Elastic Wave of Arbitrary Form in the Case of a Curved Interface.** B. Ia. Gel'chinskii. *Sov. Phys. - Dokl.*, Jan.-Feb., 1958, pp. 186–188. Translation.

**Determination of the Intensity of Head Waves in the Theory of Elasticity by the Ray Method.** A. S. Alekseev and B. Ia. Gel'chniskii. *Sov. Phys. - Dokl.*, Jan.-Feb., 1958, pp. 189–192. Translation.

**Meta-Theory of Mechanics of Continua Subject to Deformations of Arbitrary Magnitudes (Duality of Definitions of Strain, Strain Increment and Stress for Elastic and Plastic Finite Deformations).** Yoshimaru Yoshimura. *Tokyo U. Aero. Res. Inst. Rep. 343*, May, 1959. 65 pp. 16 refs. Derivation of the elastic strain tensor from the change in the metric of the Euclidian space corresponding to the material body before and after deformation. A plastic strain increment is presented, which is specified by the change in metric during the current infinitesimal deformation.

**Plane Deformation of Incompressible Material.** L. A. Tolokonnikov. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 453–455. Translation.

**Ob Obshchikh i Polnykh Formakh Reshenii Uravnenii Uprugosti.** M. G. Slobodianskii. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 468–482. 22 refs. In Russian. Analysis covering general and complete forms of solution for the equations of elasticity.

**O Variatsionnykh Metodakh Resheniia Zadach Teorii Plastichnosti.** L. M. Kachanov. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 616, 617. In Russian. Presentation of an approach for applying variational methods of solution in problems of the theory of plasticity and the theory of steady creep.

**Displacement Functions for an Isotropic Incompressible Elastic Solid.** J. Golecki. *Acad. Pol. Sci. Bul., Tech. Sci. Ser.*, No. 4, 1959, pp. 265–271. Formulation of stress-strain relations, a displacement function in rectangular coordinates, and an equation for the axially symmetric strain for solids of revolution.

**K Teorii Razrusheniia Tverdykh Tel.** D. D. Ivlev. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 618–624. 24 refs. In Russian. Survey of basic assumptions introduced into the theory of rupture of solid bodies in terms of the properties of material.

**Einige strenge Lösungen für den Spannungszustand in ebenen Verbundkörpern.** Hans Bufler. *ZAMM*, May-June, 1959, pp. 218–236. 14 refs. In German. Derivation of rigorous solutions for the state of stress in terms of pressure and shearing stress in a compounded rigid finite sheet and an elastic semi-infinite sheet. Various load cases, such as pure central pressure or tension, shear without twisting, shear with possibility of twisting, and thermal and initial stress, are covered.

**The Connections Between Stresses and Strains in Inelastic Media.** A. A. Vakulenko. *Sov. Phys. - Dokl.*, Jan.-Feb., 1958, pp. 193–196. Translation. Development by thermodynamic methods of a theory of plasticity, making greater use of the generality and other important properties of the basic laws of thermodynamics, for determining the connections between stresses and strains.

**Weiterführung der Sobreroschen Theorie des ebenen Spannungszustandes.** W. Engl. *Ing.-Arch.*, No. 2, 1959, pp. 128–136. In German. Investigation of two-dimensional stress based on the Sobrero theorem. The stress conditions along the edges of a material are studied by means of hypercomplex functions, and the applicability of the Cauchy integral is evaluated. It is shown that the normal cases of stress in straight beams can be solved with the aid of polynomials.

**On the Relation Between Stress Tensors and Rates of Straining in the General Cases of Large and Small Deformations.** G. I. Gurevich. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 672–675. Translation.

### Fatigue

**O Ravnovesnykh Treshchinakh, Obrazuiushchikhsia pri Khrupkom Razrushenii; Obshchie Predstavleniia i Gipotezy; Osesimmetrichnye Treshchiny.** G. I. Barenblatt. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 434–444. 14 refs. In Russian. Formulation of the problem of equilibrium cracks observed during brittle fracture of metals, treated as a problem in the classical theory of elasticity. The approach is based on certain general hypotheses concerning the structure of the crack and the forces of interaction of its edges, as well as on the hypothesis of finite stresses at the ends of the crack.

### Plates

**Ob Izgibe Tonkoi Polubeskonechnoi Plity, Opiraiushcheisia na Uprugii Sloi Konechnoi Tolshchiny.** R. V. Serebriannyi. *AN SSSR Dokl.*, Apr. 1, 1959, pp. 752–755. In Russian. Study of the problem covering the bending of thin semi-infinite plates supported by an elastic layer of finite thickness.

**Der Spannungszustand einer Reihe von Kräften, die in der unendlichen Halbebene angreifen.** Walter Engl. *ZAMM*, May-June, 1959, pp. 192–198. In German. Analysis of the two-dimensional state of stress in an infinite semiplane with an infinite series of concentrated forces acting upon its interior by means of hypercomplex functions. In the case of a superimposed, one-dimensional state of stress, the solution can also be applied as a first approximation for a strip under traction.

**Ein Beitrag zur exzentrisch belasteten Kreismembran.** Max Hieke. *ZAMM*, May-June, 1959, pp. 180–192. In German. Application of Weber's relation to the integration of the inhomogeneous equation of motion of a clamped circular membrane subjected to a nonconcentric uniform load not extending beyond the periphery of the membrane. The problem is solved by means of the principle of superposition.

**Tablice do Obliczania Powierzchni Wpływowych dla Pasma Płytowego.** Zbigniew Kączkowski and Marek Żórawski. *Rozprawy Inżynierskie*, No. 1, 1959, pp. 39–91. In Polish, with summaries in English and Russian. Presentation of 15 numerical tables for computing the ordinates of the influence surfaces for geometric and mechanical quantities of a plate strip.

**Free Vibration and Buckling of a Rectangular Plate with All the Edges Clamped.** W. Nowacki. *Acad. Pol. Sci. Bul., Tech. Sci. Ser.*, No. 4, 1959, pp. 249–256. Investigation of a strip with its edges clamped and loaded by transversal support forces along evenly spaced lines. Based on Fredholm's first-order integral equation, an infinite system of equations is developed where the unknowns are the Fourier coefficients of the support reactions.

**Stress Functions for Plates of Convex Polygonal Shape.** H. A. Balmer. *J. Aero/Space Sci.*, Oct., 1959, pp. 675, 676.

**An Approximate Partial Differential Equation for the Bending of an Unsymmetrical Composite Plate.** R. W. Woodhead. *Australian J. Appl. Sci.*, June, 1959, pp. 123–137. Derivation of an equation for a composite plate consisting of three separate plates—the primary, secondary, and filler plates. The equation is derived using variational calculus methods based on Castigliano's theorem of minimum potential and Reissner's theory for the bending of elastic plates.

**Experiments on the Post Buckling Behaviour of Simply Supported Panels That Change in Thickness Across the Bay.** J. P. Benthem. *Netherlands, NLL TM S. 522*, Mar., 1958. 64 pp. 12 refs. Test results on 16 panels that change their thickness discontinuously. Results are given as relations between mean (compressive) stress, edge stress, edge strain, and strain at initial buckling. By proper distribution of material along the bay width, a panel may gain in stiffness and ultimate load appreciably.

**Self-Modelling Problems in the Dynamic Bending of Plates.** Iu. A. Dem'ianov. *Sov. Phys. - Dokl.*, Jan.-Feb., 1958, pp. 197, 198. Translation.

### Sandwich Construction

**On the Local Elastic Stability of Honeycomb Face Plate Subjected to Uniaxial Compression.** R. C. Weikel and A. S. Kobayashi. *J. Aero/Space Sci.*, Oct., 1959, pp. 672–674.

### Testing Methods

**Fail-Safe Testing the 880.** J. E. Gillette. *Aircraft & Missiles Mfg.*, Sept., 1959, pp. 46–50. Discussion of test methods used to obtain protection against fatigue cracks and decompression in fuselage skins.

**Measuring Accuracy in Creep Tests. I—Influence of Eccentricity of Load.** Arne Mellgren. *USAF WADC TR 59-78, Pt. I [AD 216357]*, July, 1959. 23 pp.

**Eksperimental'noe Issledovanie Protsessa Vypuchivaniia Obolochki pri Dinamicheskom Nagruzhenii.** A. S. Vol'mir and V. E. Mineev. *AN SSSR Dokl.*, Apr. 11, 1959, pp. 1,002, 1,003. In Russian. Presentation of experimental results on the process of buckling of shells under the effect of dynamic loading.

**Unmittelbar anzeigende polarisationsoptische Messelemente für die Dehnungs- und Spannungsanalyse an Bauteilen.** G. U. Oppel. *VDI Zeitschrift*, July 11, 1959, pp. 809–816. 11 refs. In German. Discussion of two photoelastic measuring devices for the immediate indication of (a) elongation and stress in structures, and (b) the direction of the main stress. Both elements can be used for the simultaneous investigation of several points of a structure and measurements under static and dynamic load conditions.

**Spannungsoptische Untersuchung des Querstosses auf eine Kreisplatte.** H. Schwieger and V. Reimann. *ZAMM*, May-June, 1959, pp. 198–213. In German. Investigation of the effect of a central transverse impact on a circular plate by means of a photoelastic reflection method. A comparison of experimental and theoretical results is also included.

### Thermal Stress

**Stresses in a Symmetrically Heated Spherical Shell Whose Mechanical Properties Depend on Time and Temperature.** M. I. Rozovskii. *Sov. Phys. - Dokl.*, May-June, 1958, pp. 667–671. Translation.

**The Effect of Temperature Interruption on Anelastic Creep.** *ASTM Bul.*, July, 1959, pp. 61, 62. Investigation to determine whether "freezing in" of anelastic strain is feasible under significant stress conditions.

**Correlation and Extrapolation Methods of Creep Data.** M. P. Gomez. *Trend in Eng.*, July, 1959, pp. 9–15, 30–32. 38 refs. Presentation of various methods which have been proposed for predicting long-time behavior from short time tests.



XUM

### Wings

**A General Method (Depending on the Aid of a Digital Computer) for Deriving the Structural Influence Coefficients of Aeroplane Wings. I.** Appendix—**Deflections of a Simple Box Under Various Conditions. II.** Appendix A—**Stringer-Reinforced Wing of Infinite Shear Stiffness-Station Reactions at Free Edges, Free Corners, etc.** Appendix B—**Boundary-Station Formulae for Approximate Method of Deriving Shear Deflections.** Appendix C—**Boundary-Station Formulae Appropriate to the More Exact Method.** Appendix D—**Solution of the Problem of the Cantilever Square Plate by the Use of Influence Coefficients and a High-Speed Digital Computer.** D. Williams. *Gt. Brit., ARC R&M 3048* (May, 1956) 1959. 58 pp. BIS, New York, $3.60.

**Metal Wings with Pre-Stressed and Adhesive-Bonded Skins.** Hans Rebeski. (*Luftfahrttechnik*, Mar. 15, 1957, pp. 67–72.) *CIBA Aircraft Bul. 2*, May, 1958, pp. 1–8.

## Thermodynamics

**Spectral Emissivity of Carbon Dioxide from 1800–2500 cm$^{-1}$.** G. N. Plass. *OSA J.*, Aug., 1959, pp. 821–828. 14 refs. USAF-supported research.

**Rotational and Vibrational Relaxation in Diatomic Gases.** J. G. Parker. *Phys. Fluids*, July-Aug., 1959, pp. 449–462. 25 refs. Navy-supported calculations of relaxation times using as a model for the molecular interaction potential an attractive component which acts between geometrical centers of the molecules, and a repulsive component which is assumed to originate from two centers of force in each of the molecules.

### Combustion

**Stabilized Gaseous Detonation Waves.** J. A. Nicholls. *ARS J.*, Aug., 1959, pp. 607, 608. USAF-supported discussion of the concept of stationary detonation waves, as well as of the experimental procedures used and results obtained at the University of Michigan.

### Heat Transfer

**Heat Transfer Between Concentric Rotating Cylinders.** I. S. Bjorklund and W. M. Kays. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58-A-99.*) *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 175–183; Discussion, pp. 183–186; Author's Reply, p. 186. 16 refs.

**Heat Transfer from a Rotating Disk to Fluids of Any Prandtl Number.** E. M. Sparrow and J. L. Gregg. *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 249–251.

**On a Method for Solving Problems of Nonisothermal Turbulent Convection in a Channel Formed by Parallel Planes.** L. E. Ber. *Sov. Phys. - Tech. Phys.*, Jan., 1959, pp. 52–60. Translation. Development of a simple method for calculating the nonisothermal turbulent convection by introducing the term of turbulent viscosity and turbulent thermal conductivity into the equations of motion and heat transfer.

**Some Radiator Design Criteria for Space Vehicles.** J. P. Callinan and W. P. Berggren. (*ASME Av. Conf., Los Angeles, Mar. 9–12, 1959, Paper 59-Av-29.*) *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 237–244. Analysis of nonconvective radiators of single or double-active surface design for surface-temperature distribution.

**Optimum Radiator Temperature for Space Power Systems.** E. T. Pitkin. *ARS J.*, Aug., 1959, pp. 596–598. Analysis of radiator temperature for minimum system weight when power source weight varies as a function of power output, and the radiator weight as a function of temperature.

**Transient Response of Double-Fluid Heat Exchangers.** V. S. Arpaci, J. J. Redlien, and J. A. Clark. *USAF WADC TR 57-482 [AD 210251]*, Oct., 1958. 92 pp. Investigation of the dynamic response of two-fluid heat exchangers to a time-dependent temperature at the inlet of the primary fluid.

**Teploobmen v Ploskom Ustanovivshemsia Potoke Viazkoi Zhidkosti.** V. I. Merkulov. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 581, 582. In Russian. Derivations of equations for the steady heat transfer in a stationary flow of viscous liquid. The assumption of constant heat-transfer coefficients and of the known solution to the velocity field problem is introduced.

**Heat Transfer to Laminar Flow Between Parallel Plates with a Prescribed Wall Heat Flux.** R. D. Cess and E. C. Shaffer. *Appl. Sci. Res., Sect. A*, No. 5, 1959, pp. 339–344.

**An Unusual Flow Pattern May Explain the Behavior of Heat Transfer Coefficients Between Fluid Jets and Normal Surfaces.** J. M. F. Vickers. *Ind. & Eng. Chem.*, Aug., 1959, pp. 967–972. 23 refs. Measurement of heat-transfer coefficients and explanation of the behavior of laminar impacted jets.

**A Photographic Study of Boiling in the Absence of Gravity.** R. Siegel and C. Usiskin. (*ASME Av. Conf., Los Angeles, Mar. 9–12, 1959, Paper 59-Av-37.*) *ASME Trans., Ser. C - HT*, Aug., 1959, pp. 230–236. Study indicating that gravity plays a considerable role in the boiling process, especially in connection with the motion of vapor within the liquid.

## VTOL & STOL

**Vertical Take Off as a Propulsion Problem.** K. W. Mack. (*Luftfahrttechnik*, No. 4, 1958, pp. 1–16.) *Gt. Brit., RAE Lib. Transl. 813*, Apr., 1959. 37 pp. 52 refs. Discussion of the principal developments in the field of vertical take off with particular reference to the medium range airliner. The power plants used – propeller, ducted fan, and gas turbine – are compared as to their static thrust capacity, and economic applications to VTOL aircraft are briefly discussed.

**L'Avion Expérimental à Décollage à la Verticale "C-450" de la S.N.E.C.M.A.** G. Richter. (*Luftfahrttechnik*, Jan. 15, 1959, pp. 12–17.) *Docaéro*, July, 1959, pp. 29–38. In French. Survey of the problems encountered during the development of the SNECMA experimental VTOL aircraft C-450.

**A Parameter for Comparing Ground Effect Vehicles.** E. K. Liberatore. *Aero/Space Engrg.*, Oct., 1959, pp. 33–36. Proposal for comparing hovering performance of plenum chamber and annular jet configurations using a parameter titled the "factor of merit." In addition, the parameter is compared with the figure of merit used for helicopter rotors and its relation to efficiency is shown.

## Water-Based Aircraft

**The Nonlinear Problem of the Theory of a Submerged Airfoil.** A. M. Ter-Krikorov. *Sov. Phys. - Dokl.*, Mar.-Apr., 1958, pp. 255–258. Translation. Study of the steady motion of a wing submerged in an incompressible heavy fluid of finite depth.

**Concerning the Nonsingularity of the Solution of the Submerged Airfoil Problem.** N. N. Moiseev and A. M. Ter-Krikorov. *Sov. Phys.-Dokl.*, Mar.-Apr., 1958, pp. 240–243. Translation. Evaluation of the nonuniqueness of the solution to the plane problem in the theory of submerged wings. Dimensionless variables are found from an analytic function satisfying the flow conditions, the asymptotic conditions, and the conditions of pressure continuity.

**Nakhozhdenie Formy Tela po Zadannomu Impul'sivnomu Davleniiu pri Udare.** V. S. Rogozhin. *Prikl. Mat. i Mekh.*, May-June, 1959, pp. 589–591. In Russian. Determination of the shape of a body entering an incompressible liquid on the basis of a given impact pressure at shock.

**Ultraschallwelle am Tragflügelprofil bei Hohlsog. II.** F. Numachi. (*Forschung Gebiete Ing., Ausg. A*, No. 3, 1958, pp. 73–78.) *Tôhoku U. Rep. Inst. High Speed Mech., Ser. B*, vol. 10, 1959, pp. 189–213. In German. Discussion of an investigation of frequency spectra of supersonic waves generated over the airfoil by cavitation. The effects of static pressure and water temperature on the frequency dependence of the mean sound pressure, as well as on the pressure frequency of individual supersonic waves of a given frequency, are also studied.

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# IAS Section News

*(Continued from page 32)*

E. E. Hood, Joseph C. Kandiko, Harold C. Larsen, Allan U. Macartney, Col. Vincent C. Rethman, Dr. Max Scherberg, and Paul W. J. Schumacher.

**Hagerstown Section**—Newly elected officers are George C. White, Chairman; Nicholas M. Stefano, Vice-Chairman; John C. Maycock, Secretary; and Thomas V. Bollech, Treasurer. Elected to the Advisory Committee are John S. Attinello, James A. Neilson, Jr., Randall C. Smith, and Raphael J. Tiffany. Elected to the Area Nominating Committee is George W. Westphal.

**Hampton Roads Section**—Newly elected officers are John M. Swihart, Chairman; John M. Eggleston, Vice-Chairman; Lawrence K. Loftin, Jr., Secretary; and William C. Hayes, Jr., Treasurer. Elected to the Advisory Board are Hartley A. Soulé, Jean A. Roché, Eugene C. Draley, James G. McHugh, and Charles J. Donlan.

**Indianapolis Section**—Newly elected officers are H. D. Wilsted, Chairman; H. W. Welsh, Vice-Chairman; Norman Jones, Secretary; and Roger Merriman, Treasurer. Elected to the Advisory Board are William Fallis, Harold DeGroff, and Louis L. Burke.

**Niagara Frontier Section**—Newly elected officers are Edward Sing, Chairman; John M. Schuler, Vice-Chairman; John M. Cord, Secretary; and Murray Kamrass, Treasurer.

**Rocky Mountain Section**—Newly elected officers are Lt. Col. Edward M. Rex, Chairman; Dr. William H. Clohessy, Vice-Chairman; George L. Schmalbeck, Secretary; and John M. Edgar, Treasurer.

**St. Louis Section**—Newly elected officers are William J. Blatz, Chairman; Owen B. McBee, Vice-Chairman; Lawrence J. Doyle, Corresponding Secretary; Marianne Kelly, Recording Secretary; and Darrell B. Parke, Treasurer. Elected to the Advisory Board are Robert Hage, Lawrence M. Weeks, L. I. Mirowitz (Past Chairman), and F. Roever (Past Chairman).

**Texas Section**—Newly elected officers are Chairman—B. C. Scott, Chance Vought; Vice-Chairman—M. F. Towsley, Convair; Secretary—C. R. Murtaugh, Temco; and Treasurer—R. T. Sullins, Convair. Elected to the Advisory Board, from Convair, are A. T. Clemen, H. W. Hinckley, C. L. Seacord, B. G. Reed; from Chance Vought, are C. L. Turner, A. L. Jarrett, A. I. Sibila, and T. E. Allen; from Temco, are Charles Bruno and J. W. Harrell; from Bell, is R. D. Foster; elected at large is J. J. Bingham, General Electric.

**Tulsa Section**—Newly elected officers are Russell W. Brown, Chairman; Samuel G. Weir, Vice-Chairman; Peter C. Johnson, Recording Secretary; Franklin E. Peake, Corresponding Secretary; and James P. Fulton, Treasurer. Elected as representative to the Nominating Committee for Area Councilor is Clark L. Marks.

**Washington Section**—Newly elected officers are Boyd C. Meyers, II, Chairman; Lt. Col. Q. J. Goss, USAF, Vice-Chairman; Harold Andrews, Secretary; and Eugene W. Norris, Treasurer. Elected to the Advisory Board are Col. Norman C. Appold, Major Gen. Marvin C. Demler, G. L. Desmond, Harold Hoekstra, Ray Maloy, Capt. A. B. Metsger, and Dr. T. L. K. Smull.

**Wichita Section**—Newly elected officers are Glen S. McCormick, Chairman; P. A. Jackson, Vice-Chairman; Robert K. Wattson, Jr., Secretary; and Charles E. Jackson, Treasurer.

### Wichita Section

## First 1959–1960 Meeting

The first Specialist Meeting for the 1959–1960 year was held at the University of Wichita on August 20. The topic for the evening was "Vertical Take-Off."

Films of wind-tunnel model tests by the NASA, and full-scale free-flight platform tests by Hiller Aircraft Corp., were shown. A discussion period followed.

ROBERT K. WATTSON, JR., *Secretary*

## New Opportunities In Rocket Propulsion Research and Development

The United Research Corporation of Menlo Park, California, is adding to the staff of a new research and development center. This group is already exploring broad new areas in solid and liquid propellants as well as advanced rocket propulsion systems.

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If you have experience in propulsion research and development, investigate the outstanding opportunities offered at URC. Positions at all levels are now being filled in the fields of organic, analytical and physical chemistry, as well as process engineering. You will join a distinguished group of scientists directed by Dr. David Altman.

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If you'd like more information, write and tell us about yourself. Or, if you are attending the 14th Annual American Rocket Society Meeting, Washington, D. C., November 16-20, drop in and talk with our representatives at the Sheraton Park Hotel.

# UNITED RESEARCH CORPORATION OF MENLO PARK

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# REVIEWS OF *Books*

*. . . in the field of aeronautical engineering and space technology*

## AERODYNAMICS

**Aircraft Aerodynamics (Aerodinamika Samoleta); Translation.** I. V. Ostoslavskiy. Source: State Publishing House for the Defense Industry, Moscow, 1957. Prepared by Liaison Office, Technical Information Center, MCLTD, Wright-Patterson AFB, Ohio. (PB59-11993.) Washington, D.C., U.S. Dept. of Commerce, 1959. 3 vols. (808 pp.), diagrs. Part 1, $5.00; Part 2, $5.00; Part 3, $3.50.

This book discusses the principles of the methods of investigating and calculating aircraft motion: aerodynamic calculation, calculation of longitudinal and lateral stability, and controllability of aircraft.

The first part explains the methods of investigating the steady and unsteady motions of aircraft under the action of external forces, which are assumed to be specified.

In the second part, the aircraft is regarded as a system of material points, and the methods of investigating the stability and controllability of the aircraft are discussed, with particular reference to high-speed aircraft with sweptback wings and jet engines.

The book has been written in accordance with the syllabuses of the courses "Aircraft Mechanics" and "Aircraft Stability, Controllability, and Maneuverability" of the Ministry of Higher Education, U.S.S.R., and is designed for students at aviation institutes. It may, however, also be useful to engineers working in the aviation industry.

## AIRPLANES

**Proceedings of the Symposium on Self Adaptive Flight Control Systems, Held at Wright Air Development Center, January 13–14, 1959.** Edited by P. C. Gregory. (WADC TR 59-49.) Wright-Patterson AFB, Ohio, WADC, 1959. 463 pp., illus., diagrs., tables.

*Contents*: The Systems Dynamics Research Airplane, E. C. Foudriat and S. J. Sjoberg. NASA Adaptive Control System Program, W. C. Triplett. On an Adaptive Autopilot Using a Non-Linear Feedback Control System, J. D. McLean. Supervisory Control System, R. L. Cosgriff. Sperry Adaptive Flight Control System, S. S. Osder. Honeywell's History and Philosophy in the Adaptive Control Field, O. H. Schuck. A Technique for Analyzing an Adaptive Flight Control System Containing a Bi-Stable Element, L. T. Prince. Discussion of the Honeywell Adaptive Flight Control System, D. L. Mellon. A Review of Optimizing Computer Control, I. Lefkowitz and D. P. Eckman. Recent Adaptive Control Work at the General Electric Company, M. F. Marx. Dodco Research in Optimum Adaptive Flight Control, R. L. Barron. Convair Analysis and Synthesis of a Linear, Self Adaptive, Stability Augmentation System, M. Dandois. UCLA Program in Basic Research in Adaptive Control Theory, M. Margolis. Cornell Aeronautical Laboratory Presentation, P. A. Reynolds. The Aeronutronic Self-Optimizing Automatic Control System, G. W. Anderson, R. N. Buland, G. R. Cooper. Adaptive Control Systems Philospohy, Y. T. Li.

## AIRPORTS

**Airports for Jets.** John E. Peterson. Chicago, American Society of Planning Officials, 1959. 86 pp., illus., diagrs., tables. $2.50.

*Contents*: The Impact of the Jet Transport Aircraft. Air Travel Trends and the Community. Airspace—A National Resource. Characteristics of Civil Turbojet Aircraft. Aircraft Noise, The Airport and the Community. Site Characteristics and Design Factors. Protection of Airport and Community Values. Airport Location Requirements. Bibliography.

## ASTRONOMY

**Paris Symposium on Radio Astronomy; IAU Symposium No. 9 and URSI Symposium No. 1, Held From 30 July to 6 August, 1958.** Edited by Ronald N. Bracewell. Sponsored by International Astronomical Union and International Scientific Radio Union. Stanford, Calif., Stanford University Press, 1959. 612 pp., illus., diagrs., tables. $15.

*Contents: Part I. Moon and Planets.* (1) Radio Astronomy and the Solar System, F. G. Smith. (2) The Rapid Fading of Moon Echoes at 100 Mc/s, J. V. Evans, S. Evans, and J. H. Thomson. (3) Radar Observation of the Moon at 10-cm Wavelength, J. S. Hey and V. A. Hughes. (4) A Lunar Radar Study at 10-cm Wavelength, B. S. Yaplee, N. G. Roman, K. J. Craig, and T. F. Scanlan. (5) Radar Reflection Characteristics of the Moon, T. B. A. Senior and K. M. Siegel. (6) Radio Observations of the Lunar Atmosphere, B. Elsmore. (7) Observations of Venus at 8.6-mm Wavelength, J. E. Gibson and R. J. McEwan. (8) Observations of Planetary Non-Thermal Radiation, H. J. Smith and J. N. Douglas. (9) Radio Observations of the Comet Arend-Roland, G. R. Whitfield and J. Högbom. (10) Sur les Ionosphères Planétaires, F. Link. (11) Preliminary Observations at 10-cm Wavelength Using the NRL 84-Foot Radio Telescope, E. F. McClain and R. M. Sloanaker. (12) Observations of Discrete Sources at 3-cm Wavelength Using a Maser, L. E. Alsop, J. A. Giordmaine, C. H. Mayer, and C. H. Townes. (13) Concluding Lecture, A. C. B. Lovell.

*Part II. The Sun.* (14) Les Sources d'Émissions Radioélectriques du Soleil, J. F. Denisse. (15) The Structure of the Chromosphere and the Low Corona, C. de Jager. (16) A Model of the Chromosphere from Radio and Optical Data, R. G. Athay. (17) A Model of the Inner Corona Based on Radio Data, B. N. Panovkin. (18) The Quiet Sun at 88-cm Wavelength, J. Firor. (19) The Origin of the Slowly Varying Component, W. N. Christiansen and D. S. Mathewson. (20) A Comparison Between Radioheliograms and Optical Observations of the Solar Corona, M. Waldmeier. (21) Résultats Préliminaires Obtenus avec l'Interféromètre à 8 Antennes sur 3 cm. de Longueur d'Onde, M. Gutmann and J. L. Steinberg. (22) On the Regions over Sunspots as Studied by Polarization Observations on Centimeter Wavelengths, G. Gelfreich, D. Korol'kov, N. Rishkov, and N. Soboleva. (23) Radio Picture of the Sun at 3.2-cm Wavelength, V. V. Vitkevich, A. D. Kuz'min, A. E. Salomonovich, and V. A. Udal'tsov. (24) Solar Radio Bright Spots at 88-cm Wavelength, J. Firor. (25) La Composante Lentement Variable du Rayonnement Solaire sur 169 Mc/s, A. Boischot and P. Simon. (26) Etude Statistique de la Composante Lentement Variable d'Apres les Observations Entre 10,000 et 600 Mc/s, B. Vanquois. (27) A Model of the Electron Corona with Reference to Radio Observations, G. Newkirk, Jr. (28) The Solar Emission at 10-cm Wavelength, A. E. Covington. (29) A New Radio Telescope of High Resolving Power, S. E. Khaĭkin and N. L. Kaidanovskiĭ. (30) Solar Observations with the Large Pulkovo Radio Telescope at 3.2-cm Wavelength, V. N. Ikhsanova. (31) Preliminary Results of Radio-Astronomical Observations of the Annular Solar Eclipse April 19, 1958, A. P. Molchanov, C. Fan-Yun, W. Shou-Kuang, D. V. Korol'kov, E. G. Mirzabekian, and A. E. Salomonovich. (32) The Transverse Motions of the Sources of Solar Radio Bursts, J. P. Wild, K. V. Sheridan, and G. H. Trent. (33) Les Émissions de Type IV, A. Boischot. (34) Some Characteristics of Dynamic Spectra of Solar Bursts, F. T. Haddock. (35) Some Aspects of Type II Bursts, J. A. Roberts. (36) Optical Observations of Solar Disturbances Causing Type II Radio Bursts, R. G. Giovanelli and J. A. Roberts. (37) Flare-Associated Bursts at 18 Mc/s, C. Warwick and J. W. Warwick. (38) Variations in 18-Mc/s Solar and Cosmic Noise, R. Fleischer. (39) The Correlation of Solar Radio Bursts with Magnetic Activity and Cosmic Rays, A. R. Thompson. (40) Flare Puffs as a Cause of Type III Radio Bursts, R. G. Giovanelli. (41) Polarization of Bursts of Solar Radio Emission at Microwave Frequencies, H. Tanaka and T. Kakinuma. (42) Bursts of Microwave Radio Emission Associated with Sclar Flares, G. B. Gelfreich, V. N. Ikhsanova, N. L. Kaidanovskiĭ, N. S. Soboleva, G. M. Timofeeva, and V. N. Umetskiĭ. (43) Etude Interférométrique des Sources d'Activité Solaire sur 3 cm de Longueur d'Onde, M. R. Kundu. (44) Relation entre les Émissions de Rayons Cosmiques Solaires et Certains Sursauts Radioélectriques, J. P. Denisse. (45) Observation Interférométrique à 169 Mc/s des Centres *R*, Sources des Orages de Bruit, Y. Avignon, A. Boischot, and P. Simon. (46) Spectra of Short-Lived Transients in Solar Noise at 400 Mc/s, T. de Groot. (47) Fequency Drift and Fine Structure of 200 Mc/s Solar Bursts, Ø Elgarøy. (48) The Instantaneous Position and Diameter of Short Duration Bursts of Solar Radio Emission, J. A. Högbom. (49) Some Remarks on the Polarization of 200-Mc/s Solar Radio Emission, M. H. Cohen and A. D. Fokker. (50) On the Polarization of Solar Radio Emission at 1.5-m Wavelength, U. J. Alekseev and V. V. Vitkevich. (51) The 1957 November 4 Event, A. Boischot, A. D. Fokker, and P. Simon. (52) The Scattering of Radio Waves in the Solar Corona, A. Hewish. (53) Manifestations Possibles de la Couronne de Chapman dans la Radioastronomie, F. Link. (54) New Data on the Solar Supercorona, V. V. Vitkevich. (55) Eclipse de la Nébuleuse de Crabe par la Couronne Solaire, E. J. Blum and A. Boischot. (56) Concluding Lecture, M. G. J. Minnaert.

*Part III. Galactic and Extragalactic Radio Sources.* (57) The First Discovery of Point Sources, J. S. Hey. (58) The Spectra of Radio Sources, G. R. Whitfield. (59) Polarization of 10-cm Radiation of the Crab Nebula, A. D. Kuz'min and V. A. Udal'tsov. (60) The Structure of Cassiopeia A and Cygnus A Radio Sources Measured at Frequencies of 127 Mc/s and 3000 Mc/s, R. C. Jennison. (61) Optical Observations of Nonthermal Galactic Radio Sources, R. Minkowski. (62) The Radio Sources in the Cygnus Loop and $1C_{443}$, E. M. Burbidge and G. R. Burbidge. (63) Observations of Extragalactic Radio Emission, C. A. Shain. (64) The Accurate Positions of Seventeen Intense Radio Sources, B. Elsmore. (65) On the Nature of the Composite Radio Source Cygnus X, F. D. Drake. (66) Radio Emission from the Direction of the Supergalaxy, J. E. Baldwin and J. R. Shakeshaft. (67) An Attempt to Detect the 327-Mc/s Line of Galactic Deuterium, R. L. Adgie. (68) Substructure within Galactic Spiral Arms as Derived from Studies at 21 cm, R. D. Davies. (69) 21-cm Hydrogen-Line Absorption in the Spectra of Discrete Sources, C. A. Muller. (70) Neutral Hydrogen in Galactic Clusters, F. D. Drake. (71) The Distribution of Neutral Hydrogen in the Orion Region, H. van Woerden. (72) Atomic Hydrogen Survey Near the Galactic Plane, B. F. Bourke, E. T. Ecklund, J. W. Firor, H. E. Tatel, and M. A. Tuve. (73) A Survey of Neutral Hydrogen at High Galactic Latitudes, W. C. Erickson, H. L. Helfer, and H. E. Tatel. (74) Concluding Lecture, H. C. van de Hulst.

*Part IV. The Large-Scale Structure of Galaxies.* (75) Radio Evidence on the Large-Scale Structure of our Own and External Galaxies, J. L. Pawsey. (76) A Summary and Assessment of Current 21-cm Results Concerning Spiral and Disk Structures in our Galaxy, J. H. Oort. (77) Neutral Hydrogen in the Central Part of the Galactic System, G. W. Rougoor and J. H. Oort. (78) Neutral Hydrogen in Extra-Galactic Systems, L. Volders and H. C. van de Hulst. (79) Galactic Structure at Meter Wavelengths, B. Y. Mills. (80) 75-cm and 22-cm Continuum Surveys, G. Westerhout. (81) Absorption of 19.7-Mc/s Radiation in HII Regions, C. A. Shain. (82) Galactic Background Surveys and the Galactic Halo, J. E. Baldwin. (83) Hydrogen-Line Observations on the Coma Cluster, C. A. Muller. (84) Concluding Lecture, A. Blaauw.

*Part V. Discrete Sources and the Universe.* (85) The Distribution and Identification of the Sources, R. H. Brown. (86) The Problem of Confusion in Surveys of Sources, M. Ryle. (87) A Comparison of an Interferometer and Total-Power Survey of Discrete Sources of Radio-Frequency Radiation, C. Hazard and D. Walsh. (88) Studies of Radio Sources at 159 Mc/s, S. Archer, J. E. Baldwin, D. O. Edge, B. Elsmore, P. A. G. Scheuer, and J. R. Shakeshaft. (89) Résultats Préliminaires de l'Observation des Radio-Sources à l'Aide de l'Intèrferomètre de Nançay, A. Boischot. (90) On Increase of the Sensitivity and Directivity of Radio Interferometers, V. A. Sanamian and H. M. Tovmasian. (91) A Survey of Radio Sources of 3.5-m Wavelength, B. Y. Mills. (92) The Optical Identification of Radio Sources, D. W. Dewhirst. (93) Optical Identification of Southern Radio Sources, J. Basinski, B. J. Bok, and K. Gottlieb. (94) The Nature of the Radio Sources, M. Ryle. (95) The Relation of Radio Astronomy to Cosmology, F. Hoyle. (96) Remarks on Cosmology, G. C. McVittie. (97) Concluding Lecture, R. Minkowski.

*Part VI. Mechanisms of Solar and Cosmic Emission.* (98) The Theoretical Explanation of Radio Emission, G. R. Burbridge. (99) On the Possibility of Observing Radio Emission from Flare Stars, E. Schatzman. (100) Radio-Noise Measurements on the Passage of Solar Particles Through the Corona, T. R. Hartz. (101) Synchrotron Radiation and Solar Radio Outbursts at

Microwave Frequencies, T. Takakura. (102) The Origin of the Belt of Galactic Radio Waves, H. Tunmer. (103) On the Mechanisms of Sporadic Solar Radio Emission, V. L. Ginzburg, and V. V. Zheleznikov. (104) Cosmic Rays and Radio Waves as Manifestations of a Hot Universe, T. Gold and F. Hoyle. (105) Radio Astronomy and the Origin of Cosmic Rays, V. L. Ginzburg. (106) The Determination of the Energy Distribution of Relativistic Electrons by the Frequency Distribution of their "Synchrotron Radiation," G. Wallis. (107) Concluding Lecture, F. Hoyle. *List of Participants. Index.*

## CHEMISTRY

**Vistas in Free-Radical Chemistry.** Edited by W. A. Waters. Published in Memoriam to Dr. Morris S. Kharasch. New York, Pergamon Press, Inc., 1959. 251 pp., diagrs., tables. $12.50.

*Contents: Reprints of 12 Selected Papers of M. S. Kharasch (edited 1958).* The Decomposition of Unsymmetrical Mercuri-Organic Compounds: A Method of Establishing the Relative Degree of Electronegativity of Organic Radicals, M. S. Kharasch and R. Marker. The Peroxide Effect in the Addition of Reagents to Unsaturated Compounds—I. The Addition of Hydrogen Bromide to Allyl Bromide, M. S. Kharasch and F. R. Mayo. The Peroxide Effect in the Addition of Reagents to Unsaturated Compounds—XVI. The Addition of Thioglycolic Acid to Styrene and Isobutylene, M. S. Kharasch, A. T. Read, and F. R. Mayo. Reactions of Atoms and Free Radicals in Solution—X. The Addition of Polyhalomethanes to Olefins, M. S. Kharasch, E. V. Jensen, and W. H. Urry. Catalytic effects in the Bromination of Toluene, M. S. Kharasch, P. C. White, and F. R. Mayo. Chlorinations with Sulfuryl Chloride—I. The Peroxide-Catalyzed Chlorination of Hydrocarbons, M. S. Kharasch and H. C. Brown. Reactions of Atoms and Free Radicals in Solution—I. A Study of the Substitution of Hydrogen on an Asymmetric Carbon Atom—the Chlorination of Primary Active Amyl Chloride, M. S. Kharasch, H. C. Brown, and T. H. Chao. Reactions of Atoms and Free Radicals in Solution—IV. Decomposition of Acetyl Peroxide in Aliphatic Acids—A New Synthesis of Succinic Acid and Its Substitution Derivatives, M. S. Kharasch and M. T. Gladstone. The Role of Peroxides in Addition Reactions of Olefins and in the Polymerization of Unsaturated Compounds, M. S. Kharasch. Grignard Reagents: Their Reducing Action and Rates of Addition, M. S. Kharasch and S. Weinhouse. Factors Determining the Course and Mechanisms of Grignard Reactions—IV. The Effect of Metallic Halides on the Reaction of Aryl Grignard Reagents and Organic Halides, M. S. Kharasch and E. K. Fields. Factors Influencing the Course and Mechanisms of Grignard Reactions—XX. The Cleavage of Ethers by Grignard Reagents in the Presence of Cobaltous Halides, M. S. Kharasch and R. L. Huang.

The Discovery of the Peroxide Effect, F. R. Mayo. The Contributions of Morris S. Kharasch to Polymer Chemistry, C. Walling. Some Trends in the Study of Free-Radical Reactions in Solution, W. A. Waters. The Chemistry of Free Radicals in the Gas Phase, K. O. Kutschke and E. W. R. Steacie. Homolytic Aliphatic Substitutions, H. C. Brown. Homolytic Aromatic Substitution, D. H. Hey. Some New Chain Reactions Induced by Acyl Peroxides, G. A. Rasuwajew. Electrophilic Addition to 1 : 1 : 1-Trichloropropene, A. N. Nesmeyanov, R. Kh. Freidlina, L. I. Zakharkin, V. N. Kost, R. G. Petrova, A. B. Belyavsky, and A. B. Terentiev. The Reaction of Benzyl Ethers with Free *tert.*-Butoxy Radicals, R. L. Huang and S. S. Si-Hoe.

## DIRECTORIES

**Directory of Guided Missiles: Specifications, Systems, Components, Materials, Contractors; Airframes, Warheads, Guidance, Ground-Support, Propulsion, Equipment.** Prepared by the Editors of *Federal Procurement & Subcontracts Daily* and by *R & D*, The Research & Development Weekly. Long Island City, N.Y., Federal Procurement Publications, Inc., 1958. 176 pp. $15.

**Directory of Missile Manufacturers in the State of Connecticut.** Prepared by Connecticut Development Commission. Hartford, Conn., State Office Building, 1958. 75 pp.

*Section A* of the directory lists manufacturers actually performing missile work, and *Section B* lists those not doing such work but with the interest and ability to do so. Those manufacturers who have research and development facilities are listed in *Section C*.

## DOCUMENTATION

**Providing U.S. Scientists with Soviet Scientific Information.** Rev. Ed. Prepared by Office of Science Information Service, National Science Foundation. Washington, The Foundation, May, 1959. 36 pp., tables.

In concerning itself with making the results of Soviet scientific research readily available to U.S. scientists, this pamphlet discusses the problem in two phases: the form and extent of the Soviet information that should be made available in the U.S., and what is actually being done to make this information accessible to U.S. scientists.

## ELECTRONICS

**1959 National Telemetering Conference: Investigation of Space: Papers Presented at Denver, Colo., May 24–27, 1959.** Sponsored by American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of the Aeronautical Sciences. 411 pp., illus., diagrs., tables. $4.50.

*Contents*: Communication Efficiency of Space Telemetry Systems, R. W. Sanders. Comparative Merits of Analog and Digital Telemetering, L. C. Watson and M. Goldstein. New Developments in PCM Telemetry, R. E. Marquand. The Influence of FM-FM Telemetry Component Characteristics on System Performance, O. J. Ott. A Comparison of an Identical Vacuum Tube and Transitor Telemetry System, N. A. Lowy. Distortion in FM-FM Systems and Its Effect on System Accuracy, W. O. Frost. High Accuracy Telemetry of Inertial Guidance Performance, J. F. Meyer. Accuracy and Reliability of the Sandia 220 MG Telemetry System, J. H. Scott. Some Considerations of the Effects of Nuclear Radiation Environments on Precision Airborne Instrumentation, J. M. Rau, Jr. Variable Inductance Modulation of a Transistorized Subcarrier Oscillator, C. E. Land. A Solid State Multiplexer and PCM Encoder, T. P. Bothwell, R. C. Baron, and R. J. Sutherby. A Transistorized Active Low Pass Filter with One CPS Corner Frequency, R. C. Onstad. Semiconductor Device Operation in A Pulsed Nuclear Environment, W. A. Bohan, J. D. Maxey and R. P. Pecoraro. Some Coding Concepts to Conserve Bandwidth, L. G. Zukerman and I. Ross. The PCM-PS Telemetry System, H. N. Putschi and E. Niemann, Jr. A New Practical Approach to Subcarrier Pre-Emphasis, W. E. Hane. Voltage-Transfer Low-Level Commutation System, M. E. Martin and W. M. Phillips. A Transfer Function Computer, J. Brown. A Low-Level, High-Speed Sampling Switch, E. J. Young. Variable-Reluctance DC Transducer, O. K. Kowallis. High Density Magnetic Tape Recording of Digital Data, M. A. Wells. Tra-Decom—A Transistorized PAM Decommutator, P. R. Palmer and J. E. Scheibner. A Deviation Standard for FM Systems, H. J. Wood, Jr. A Trailer-Installed Flight Test Monitoring and Control System, S. F. Higgins. Processing and Presentation of Data from Outer Space, J. M. Seehof and B. W. Washburn. An Automatic Instrumentation Analog Data Processing System, E. G. Hoefs and N. F. Bolling. An Analog On-Line Data Reduction System for Engine Testing, S. L. Dresser and J. D. Dunlop. Simple Computation Techniques for Telemetry Data Reduction Systems, G. Birkel, Jr., and M. C. Burns. Digital Data Processing of PDM and FM-FM Telemetry, W. E. Leever. Physiological Telemetry in the Space Age, M. A. McLennan. The Requirements for Biomedical Monitoring in Space Flight, R. W. Lawton. Physiological Tranducers for Measurements in Space Vehicles, W. Welkowitz, M. Traite, C. Purpuro, and J. Kilduff. Biomedical Measuring Circuitry, J. T. Powell. Transmission of Microwave Telemetry Signals from a Re-Entering Vehicle, K. Baldwin. Parameters and Techniques Applicable to Ultra-Long-Range Communication with Solar System Probes, J. J. Downing. Space Navigation by Correlation, P. Zilczer. Radio Links for Spaceflight, J. H. W. Unger. An Ultralinear Frequency-Modulated Transmitter, R. E. Lee. A State-of-the-Art Receiver for 2200 MC Telemetry, S. E. Smith and H. Scharla-Nielsen. Miniaturized Telemetry Slot Antennas for Missile Applications, M. Yaffe. R-F Multiplexing of Telemetry Transmitters, W. H. Harrison.

**Advances in Semi-Conductor Science; The Proceedings of the Third International Conference on Semi-Conductors, Held at the University of Rochester, U.S.A., August 18–22, 1958.** Conference Chairman, J. Bardeen; General Editor, H. Brooks. New York, Pergamon Press, Inc., 1959. 53 pp., diagrs., tables. $15.

The volume consists of 136 papers which were presented at the conference, and are grouped under their respective topics: band theory, recombination and impurity centers, surfaces, dislocations, excitons, general, transport, optical properties, ionic crystals, magneto-optical effects, thermal conduction and thermomagnetic effects, excitons and photons, semiconducting compounds, large band gap semiconductors, resonance, and galvomagnetic effects.

**The Properties, Physics, and Design of Semiconductor Devices.** John N. Shive. Princeton, N.J., D. Van Nostrand Co., Inc., 1959. 487 pp., diagrs., tables. $9.75.

This book provides a comprehensive physical theory of semiconductors and device operation, including the thermistor, the varistor, the photoelectric cell, and the transistor. In level, depth, and topical content, it attempts to bridge the gap between elementary expositions of the semiconductor story and the highly theoretical treatments. Stress has been placed upon graphic descriptions of the electronic processes occurring in semiconductors as an introduction to more advanced analytical study. The subject material falls into two main divisions: *Part 1* gives a discussion of various semiconductor devices from an empirical point of view and describes their fabrication, properties, characteristics, and typical applications; *Part 2* is devoted to the physics of solids and the applications of solid-state electronics to the design of practical devices.

The author is a member of the Technical Staff of Bell Telephone Laboratories, where he has presented the material of the text in a graduate-level training course to newly recruited technical staff employees.

## FLUID MECHANICS

**Applied Hydrodynamics.** H. R. Vallentine. London, Butterworths Scientific Publications, 1959. 272 pp., diagrs., tables. $10.

This book is intended for use in universities as an introduction to hydrodynamics for students of applied mathematics, and as a course in fluid dynamics for senior and postgraduate students in civil, mechanical, and aeronautical engineering. In its approach to the subject, the book has a bias toward practical application, with particular attention being paid to the provision of detailed physical explanations of such concepts as stream function, potential function, and conformal transformation, as a prelude to the more formal mathematical treatment of these topics.

In his capacity as Senior Lecturer in Civil Engineering, the author has presented the material in lectures over the past 5 years to senior and graduate students in Civil Engineering at the University of New South Wales, Australia.

## FUELS & LUBRICANTS

**Fuels and Lubricants.** Milosh Popovich and Carl Hering. New York, John Wiley & Sons, Inc., 1959. 312 pp., diagrs., tables. $8.50.

Summarizing material from various sources, this survey of the field of fuels and lubricants discusses boiler, internal combustion engine, and jet fuels, as well as rocket propellants and nuclear fuels. Some of the features include a discussion of the desirable properties of fuels and lubricants; the ASTM tests, which are used to measure properties, and the interpretation, limitation, and significance of these tests; the advantages, disadvantages, and uses of synthetic lubricating oils; a tabulation of octane numbers of many pure hydrocarbons; a review of hydrocarbon chemistry; and specifications for fuels and lubricants.

The book is designed for college-level courses and is the product of Milosh Popovich, Assistant Dean of Engineering, Oregon State College, and Carl Hering, Professor of Chemical Engineering, U.S. Naval Postgraduate School.

**Solid Propellant and Exothermic Compositions.** James Taylor. New York, Interscience Publishers, Inc., 1959. 153 pp., illus., diagrs., tables. $4.25.

This book deals with the use of chemicals as a source of energy, especially in connection with explosives and rocket propulsion. Concerned primarily with reactions in the solid state, the text surveys the wide range of chemical compositions which have been developed as sources of energy for various applications, and also describes the applications themselves. Eleven chapters are devoted to the following aspects of the subject: self-sustained exothermic chemical reactions; gunpowder and pyrotechnics; explosives; initiating explosives; propellants, low-temperature gas-producing reactions based on nitrites, and the "hydrox" blasting device; ammonium nitrate, guanidine nitrate, and nitroguanidine compositions; rocket motors; solid charges for rockets and propulsion; power cartridges; and gasless reactions.

The author has derived his material mainly from work which has been carried out in the Nobel Division Laboratories of Imperial Chemical Industries over the past 30 years.

## HUMAN ENGINEERING

**Research Techniques in Human Engineering.** Alphonse Chapanis. Baltimore, The Johns Hopkins Press, 1959. 316 pp., diagrs., tables. $6.00.

This practical handbook for human engineering presents a compilation of operational methods and problems taken from the various fields of industrial engineering, psychology, anthropometry, physiology, and statistics. The purpose is twofold: to describe some of the methods available to the human engineer for collecting trustworthy data on men and machines and the relationships between them; and to discuss some principles and guide lines concerning ways of doing dependable studies on people. Much of the writing of the monograph was done while the author was a consultant employed by the Operational Applications Laboratory of the AFCRC, under a commission from the Executive Council of the Joint Services Steering Committee for the Human Engineering Guide to Equipment Design. The present monograph is a revision and expansion of *The Design and Conduct of Human Engineering Studies* published in 1956 and financed by Contract Nonr-1268(01), Project NR 145-075, between the Office of Naval Research and the San Diego State College Foundation.

The author is Professor of Psychology and Industrial Engineering, The Johns Hopkins University.

## LAWS AND REGULATIONS

**First Colloquium on the Law of Outer Space, The Hague, 1958; Proceedings.** Edited by Andrew G. Haley and Welf Heinrich, Prince of



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Hanover. Vienna, Springer-Verlag, 1959. 126 pp., diagrs. $4.50.

*Contents:* Introduction. A Light from the Past to Show Up The Legal Problems of Our Age of Space, Fr. W. von Rauchhaupt. Space Age Presents Immediate Legal Problems, A. G. Haley. Problems in Establishing a Legal Boundary between Air Space and Space, W. Heinrich, Prince of Hanover. Contribution, V. Alessandrone-Gambardella. A Contribution to the Problem of Space Law Establishing a Technical and Practical Limit to Political Sovereignty in Space, L. de Gonzaga Bevilacqua. Principles for a Declaration with Reference to the Legal Nature of the Moon, A. A. Cocca. The Problem of a Definition of "Air Space," J. C. Cooper. An American View of Jurisdiction in Outer Space, G. J. Feldman. A Definitive Study of the Concept and Scientific Strategy of Outer Space. The Challenge to all Nations to Support a Just System of Space Law, J. G. Fulton. The Community of Law and Science, E. Galloway. Contribution, K. W. Gatland. Contribution, F. Gerlach. On the Threshold of Space; Toward a Cosmic Law. Problems of the Upward Extent of Sovereignty, S. Gorove. Technical Proposals, D. L. Herr. Comments, R. Homburg. Definition of Air Space, R. Jastrow. Space Law and the Fourth Dimension of Our Age, K. B. Keating. Observations, E. Pépin. The Internationalization of Outer Space and the Unification of World Astronautical Strategy; the Ecumenical Nature of Astronautics, F. A. Pereira. The Hellenic Contribution in Astronautics, S. Plakidis. Design for a Law of Space, J. Rivoire. The Responsibility of States for the Damage Caused by Launched Space-Bodies, I. H. Ph. de Rode-Verschoor. The Need for a New System of Norms for Space Law and the Danger of Conflict with the Terms of the Chicago Convention, M. Smirnoff. Definitions and Subdivisions of Space. Bioastronautical Aspect, H. Strughold. Remarks, B. Tuneld. Remarks, O. Wolczek. A Code for a New Frontier, Ph. B. Yeager.

### MATHEMATICS

**Mathematics in Physics and Engineering.** J. Irving and N. Mullineux. (Pure and Applied Physics, Vol. 6.) New York, Academic Press, Inc., 1959. 883 pp., diagrs., tables. $11.50.

This book describes the analytical and numerical (calculator) methods that arise most frequently in present-day pure and applied science. It is not the intention of the authors to derive the equations of mathematical physics but to give methods for their solution. Emphasis is placed upon the application of the mathematical theory, and worked examples illustrating and extending the theory and its ramifications are drawn from many difficult fields of applied science. The twelve chapters are devoted to an introduction to partial differential equations, ordinary differential equations, Frobenius' and other methods of solution, Bessel and Legendre functions, the Laplace and other transforms, matrices, analytical methods in classical and wave mechanics, calculus of variations, complex variable theory and conformal transformations, the calculus of residues, transform theory, numerical methods, and integral equations. An appendix of pure mathematics is included to supplement the text.

J. Irving is associated with The University, Southampton, England, and N. Mullineux with Birmingham College of Technology, Birmingham, England.

**On Numerical Approximation; Proceedings of a Symposium Conducted by the Mathematics Research Center, United States Army, at the University of Wisconsin, Madison, April 21–23, 1958.** Edited by Rudolph E. Langer. Madison, Wis., The University of Wisconsin Press, 1959. 462, pp., diagrs. $4.50.

*Contents:* On Trends and Problems in Numerical Approximation, A. M. Ostrowski. Linear Spaces and Approximation Theory, R. C. Buck. Operational Methods in Numerical Analysis Based on Rational Approximations, Z. Kopal. On the Numerical Integration of Periodic Analytic Functions, P. J. Davis. Some New Divided Difference Algorithms for Two Variables, H. E. Slazer. Numerical Evaluation of Multiple Integrals, P. C. Hammer. Optimal Approximation and Error Bounds, M. Golomb and H. F. Weinberger. The Rationale of Approximation, A. Sard. On External Approximations, J. L. Walsh. Numerical Methods of Tchebycheff Approximation, E. L. Stiefel. Minimax Methods in Table Construction, L. Fox. Existence of Essentially Nonlinear Families Suitable for Oscillatory Approximation, T. S. Motzkin. On Variation Diminishing Approximation Methods, I. J. Schoenberg. Approximation by Functions of Fewer Variables, M. Golomb. Extremal Approximations—A Summary, J. P. C. Miller. Survey of Recent Russian Literature on Approximation, R. C. Buck. The Quotient-Difference and Epsilon Algorithms, F. L. Bauer. Some Sufficient Conditions for the Existence of an Asymptotic Formula or an Asymptotic Expansion, J. B. Rosser. The Estimation of (Power) Spectra and Related Quantities, J. W. Tukey. Approximation in Partial Differential Equations, L. Collatz. Special Polynomials in Numerical Analysis, J. Todd. Index.


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**Radar Meteorology: A Complete Guide to the Use of Radar for Studying and Forecasting Weather.** Louis J. Battan. Chicago, The University of Chicago Press, 1959. 161 pp., illus., diagrs., tables. $6.00.

The advances of the last 15 years in radar theory and technique are summed up in this volume. It covers the meteorological use of radar instruments, the meteorological quantities measured by radar, and the relationship of such measurements to more conventional meteorological parameters.

The author is Professor of Meteorology and Climatology and Associate Director of the Institute of Atmospheric Physics at the University of Arizona.

**Turbulent Transfer in the Lower Atmosphere.** C. H. B. Priestley. Chicago, The University of Chicago Press, 1959. 130 pp., diagrs., tables. $3.75.

The author, Chief of the Division of Meteorological Physics, Commonwealth Scientific and Industrial Research Organisation, Australia, offers in this volume a detailed treatise on the study of atmospheric disturbance near the ground. The text is based on a series of lectures presented at the University of Chicago in 1957, and the subject matter has been restricted to the vertical motions and distributions of the elements and transports which these achieve. After a brief introduction, various chapters are devoted to discussions of the eddy flux and its measurement, the shearing stress and the wind profile, heat convection and the temperature profile, the spectrum of turbulence and the structure of free convection, theories of buoyant motion, evaporation, and evolutionary aspects of energy transfer.

## PHYSICS

**Low Temperature Physics & Chemistry; Proceedings of the Fifth International Conference on Low Temperature Physics and Chemistry, Held at the University of Wisconsin, August 26–31, 1957.** Edited by Joseph R. Dillinger. Madison, Wis., The University of Wisconsin Press, 1958. 676 pp., illus., diagrs. $6.00.

The 225 papers contained in this volume were contributed by scientists from 14 different countries and are organized by subject into the following 26 divisions: viscosity and flow properties of liquid $He^4$; heat flow in and specific heat of liquid $He^4$; dielectric constant, refractive index, film thickness, and rotation of liquid $He^4$; heat diffraction, sound transmission, and structure of $He^4$; liquid $He^3$; and $He^4$; theory of liquid $He^4$ and liquid $He^3$; solutions of $He^3$ in $He^4$; the temperature scale and temperature measurement; instrumentation; $He_3$ Dewar systems, heat switches, a liquefier, computer elements, techniques; theories of superconductivity; properties of some superconductors; intermediate state of superconductors; superconductivity of thin films, contract resistance, pressure effects and volume changes in superconductivity; millimeter wave absorption and the paramagnetic effect in superconductors; thermal and electrical conductivity of elements and compounds; thermal and electrical conductivity of alloys; measurements of specific heats of solids; analyses of specific heat data; De Haas-Van Alphen and other oscillatory effects; magnetoresistance, thermolelectricity, resistivity, and Hall effect; mechanical properties of solids including solidified gases; paramagnetism and resonances; magnetic susceptibilities; ferromagnetism and general magnetic properties; thermal expansion, adsorption spectra, dielectric properties, rotational transitions, polymers, and nuclear magnetic resonance; nuclear orientation experiment.

**Fast Reactions in Solids.** F. P. Bowden and A. D. Yoffe. London, Butterworths Scientific Publications, 1958. 164 pp., illus., diagrs., tables. $7.00.

This monograph deals with recent experimental investigations into the mechanism by which an explosion can be initiated in a solid, in particular with the mechanism by which a crystal can decompose when subjected to heat, light, shock, or nuclear radiation. High resolution electron microscopy combined with electron diffraction is used to investigate the early stage of decomposition, and high-speed photography and fast electronic methods are employed to follow the rapid reaction. Since some of the observations made in the studies of slow decomposition are relevant to the subject of fast reactions in solids, both of these aspects and the growth to explosion are discussed. The eight chapters of text cover slow decomposition of crystals, thermal explosions, structure and stability of inorganic compounds, initiation of explosion by shock, initiation of explosion by light, decomposition and ignition by nuclear particles and ionizing radiations, spontaneous explosions, and fast growth of explosion.

Both authors are with the Laboratory for the Physics and Chemistry of Solids, Department of Physics, Cambridge University.

## RUSSIAN LANGUAGE

**Scientific Russian; A Concise Description of the Structural Elements of Scientific and Technical Russian.** George E. Condoyannis. New York, John Wiley & Sons, Inc., 1959. 225 pp., diagrs., tables. $3.50.

This grammer is meant primarily for beginners with no previous knowledge of Russian, and may be used for classroom or individual instruction. It presents a study of the basic structure of the language which, with the aid of a dictionary, should lead to the acquisition of a reading knowledge of Russian adequate to cope with technical articles and books. The approach is analytic rather than synthetic. After a review of the structure of the Russian language, the text presents a lesson on basic elements—the grammatical units and patterns encountered repeatedly in technical prose. Subsequent lessons serve mainly to fill in the details of the overall pattern.

The author is Associate Professor of Modern Languages, Saint Peter's College, and has evolved the grammar from many years of teaching reading-aim courses in Russian at the Massachusetts Institute of Technology.

## SAFETY

**Medical Aspects of Flight Safety (The Unexplained Aircraft Accident).** NATO AGARD. Edited by E. Evrard, P. Bergeret, and P. M. Van Wulfften Palthe. (AGARDograph No. 30.) New York, Pergamon Press, Inc., 1959. 308 pp., illus., diagrs., tables. $11.20.

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## SPACE TRAVEL

**Advances in Astronautical Sciences, Vol. 4; Proceedings of the Fifth Annual Meeting of the American Astronautical Society, Held in Washington, D.C., December, 1958.** New York, Plenum Press, Inc., 1959. 460 pp., illus., diagrs., tables. $8.00.

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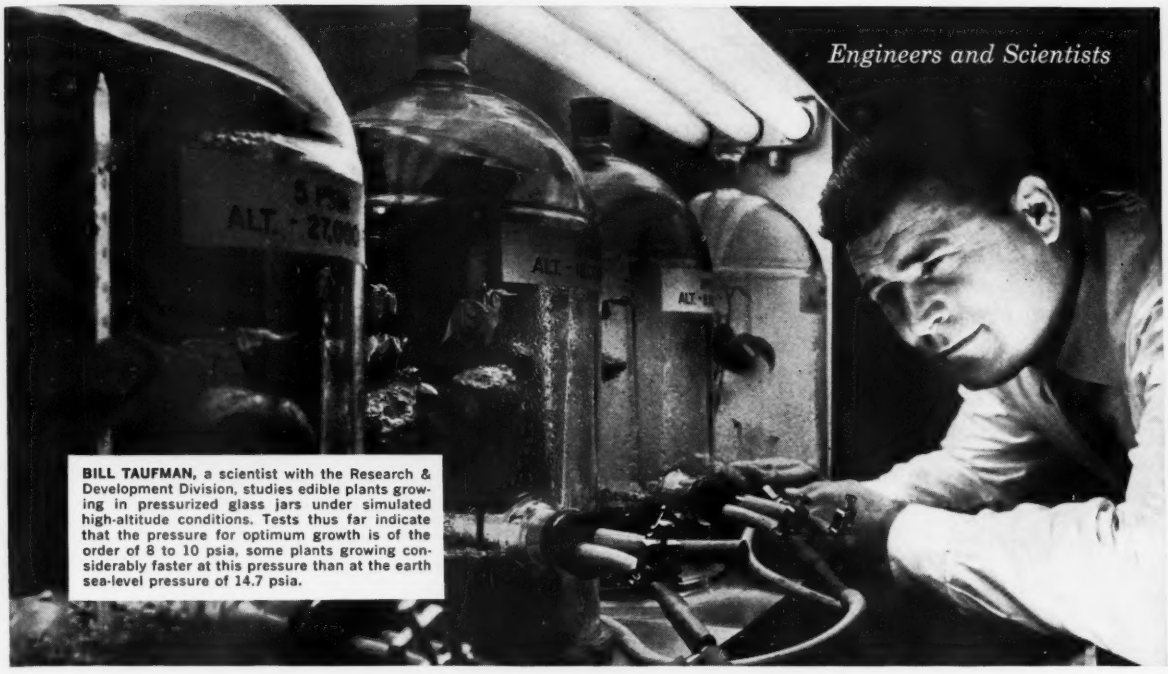


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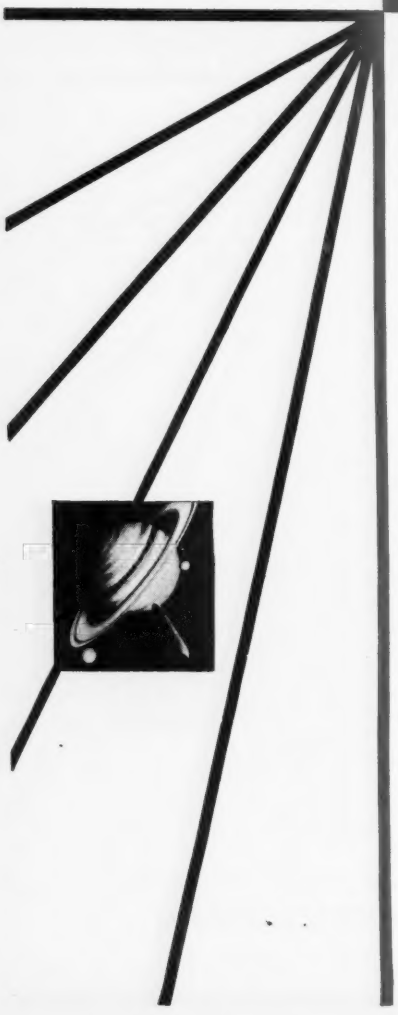

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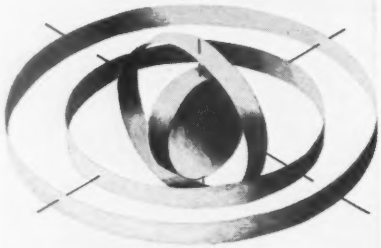

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